A PROSPECTIVE STUDY EVALUATING THE EFFECTIVENESS OF EPIDURAL VOLUME EXTENSION WITH NORMAL SALINE IN COMBINED SPINAL EPIDURAL ANAESTHESIA FOR LOWER LIMB ORTHOPAEDIC SURGERIES USING LOW DOSE INTRATHECAL HYPERBARIC BUPIVACAINE

Dissertation submitted in partial fulfilment of the requirements for award of the degree M.D. (Anaesthesiology) Branch X

GOVT. KILPAUK MEDICAL COLLEGE

CHENNAI-10

THE TAMIL NADU DR. M.G.R. MEDICAL UNIVERSITY

CHENNAI, TAMILNADU

APRIL 2017

CERTIFICATE

This is to certify that this dissertation entitled "***A PROSPECTIVE STUDY EVALUATING THE EFFECTIVENESS OF EPIDURAL VOLUME EXTENSION WITH NORMAL SALINE IN COMBINED SPINAL EPIDURAL ANAESTHESIA FOR LOWER LIMB ORTHOPAEDIC SURGERIES USING LOW DOSE INTRATHECAL HYPERBARIC BUPIVACAINE***" submitted by **Dr. ASHWINI.S** in partial fulfilment for the award of the degree Doctor of Medicine in Anaesthesiology by **The Tamilnadu Dr. M.G.R. Medical University, Chennai** is a bonafide work done by her at **GOVERNMENT KILPAUK MEDICAL COLLEGE, CHENNAI** during the academic year 2014-2017.

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DECLARATION

I, **Dr. ASHWINI.S**, solemnly declare that this dissertation, entitled "***A PROSPECTIVE STUDY EVALUATING THE EFFECTIVENESS OF EPIDURAL VOLUME EXTENSION WITH NORMAL SALINE IN COMBINED SPINAL EPIDURAL ANAESTHESIA FOR LOWER LIMB ORTHOPAEDIC SURGERIES USING LOW DOSE INTRATHECAL HYPERBARIC BUPIVACAINE***", has been prepared by me, under the expert guidance and supervision of **Prof.Dr.T.Murugan,M.D.,D.A**, Professor and HOD, Department of Anaesthesiology, Government Kilpauk Medical College and Hospital, Chennai and submitted in partial fulfilment of the regulations for the award of the degree **M.D.(Anaesthesiology)** by **The Tamil Nadu Dr. M.G.R. Medical University** and the examination to be held in April 2017.

This study was conducted at Government Kilpauk Medical College Hospital and Government Royapettah Hospital, Chennai. I have not submitted this dissertation previously to any university for the award of any degree or diploma.

Place: Chennai

Date:

(DR.ASHWINI.S)

DECLARATION BY THE GUIDE

This is to certify that this dissertation entitled "***A PROSPECTIVE STUDY EVALUATING THE EFFECTIVENESS OF EPIDURAL VOLUME EXTENSION WITH NORMAL SALINE IN COMBINED SPINAL EPIDURAL ANAESTHESIA FOR LOWER LIMB ORTHOPAEDIC SURGERIES USING LOW DOSE INTRATHECAL HYPERBARIC BUPIVACAINE***" submitted by **Dr. ASHWINI.S** in partial fulfilment for the award of the degree Doctor of Medicine in Anaesthesiology by **The Tamilnadu Dr.M.G.R. Medical University, Chennai** is a bonafide work done by her at **GOVERNMENT KILPAUK MEDICAL COLLEGE, CHENNAI** during the academic year 2014-2017, under my guidance and supervision.

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INTRODUCTION

Combined spinal epidural anaesthesia technique for p relief for orthopaedic procedures has gained popularity. This tech as a one time procedure where first the epidural space is located a administration of either a combination of local anaesthetic and o component separately is done, followed by catheter insertion in space. It combines the advantages of rapid onset and the reliabilit obtained spinally along with the flexibility given by epidural cath the disadvantages of either technique used alone.

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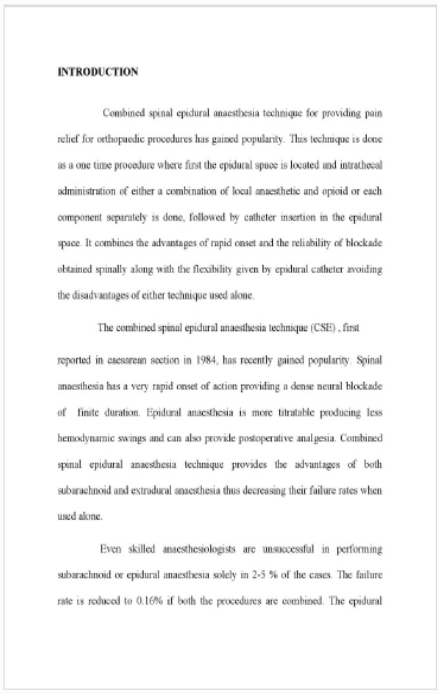

INTRODUCTION

Combined spinal epidural anaesthesia technique for providing pain relief for orthopaedic procedures has gained popularity. This technique is done as a one time procedure where first the epidural space is located and intrathecal administration of either a combination of local anaesthetic and opioid or each component separately is done, followed by catheter insertion in the epidural space. It combines the advantages of rapid onset and the reliability of blockade obtained spinally along with the flexibility given by epidural catheter avoiding the disadvantages of either technique used alone.

The combined spinal epidural anaesthesia technique (CSE) , first reported in caesarean section in 1984, has recently gained popularity. Spinal anaesthesia has a very rapid onset of action providing a dense neural blockade of finite duration. Epidural anaesthesia is more titratable producing less hemodynamic swings and can also provide postoperative analgesia. Combined spinal epidural anaesthesia technique provides the advantages of both subarachnoid and extradural anaesthesia thus decreasing their failure rates when used alone.

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Even skilled anaesthesiologists are unsuccessful in performing subarachnoid or epidural anaesthesia solely in 2-5 % of the cases. The failure rate is reduced to 0.16% if both the procedures are combined. The epidural volume extension adds colour to combined spinal epidural anaesthesia technique where the onset and the level of blockade obtained spinally is

enhanced by administering saline or local anaesthetic via the epidural catheter. The ideology behind this is the volume effect accomplished by injecting saline epidurally which would result in intrathecal compression and cephalad migration of spinal local anaesthetic.

This study was aimed to identify the effectiveness of block profile provided by extending the epidural volume with normal saline for lower limb orthopaedic surgeries using a low dose intrathecal hyperbaric bupivacaine without causing hemodynamic changes. The majority of lower extremity orthopaedic surgery patients are old age and have multiple coexisting medical problems. Ensuring hemodynamic stability in these patients requires selection of appropriate techniques of regional anaesthesia, focussing on maintaining a safe and desirable level of blockade and limiting extensive sympathectomy.

COMBINED SPINAL EPIDURAL ANALGESIA

ANATOMY

The epidural space is the most experimented cavity in human beings. It was first described by Corning1 in 1901. The anatomical space between the duramater and the vertebral canal is called the epidural space. It was thought to be a real space while in reality it is merely a potential space.

24 individual vertebrae forms the vertebral column constituting 7 cervical, 12 thoracic, 5 lumbar while the fused vertebrae includes 5 sacral and 3 to 5 coccygeal bones remaining rudimentary. The epidural and the subarachnoid spaces are housed and protected by these vertebrae. The fusion of the membranes of the medulla spinalis and the duramater overlying the periosteum at the foramen magnum forms the upper boundary of the epidural space, whereas the sacrococcygeal membrane forms the lower limit. The bodies of vertebrae along with intervertebral discs and posterior longitudinal ligament binds the epidural space anteriorly while laterally it is encircled by the pedicles and intervertebral foramina.

EMBRYOLOGY

At the gestational age of 13 weeks, the connective tissues plug the epidural space and the posterior longitudinal ligament and the duramater are tethered. Three stages differentiate the evolvement of the epidural space inside the connective tissue at the 13^{th} week subsequently. These are namely the

primary epidural space formed in embryos measuring 16-31 mm crown rump length , reduction in the volume of the primary epidural space occurs when embryos measure about 35-55 mm crown rump length and formation of the secondary epidural space occurs at the embryological growth phase of 60-70mm crown rump length.

The attachment of the vertebral body to the posterior longitudinal ligament lateral to the midline and to the dorsal margin of intervertebral disc occurs at the 15th week of embryonic life. At week 21, the binding between the duramater and posterior longitudinal ligament is ligament like at the vertebrae. At week 32, the superficial layer of posterior longitudinal ligament and the duramater are adherent. Groups of adipocytes begin to develop at the 39^{th} week.

The upper thoracic regions of the spinal cord has the most roomy epidural space. The epidural space at the level of C7-T1 in adult measures 0.4 mm posteriorly, in the upper thoracic region it measures about 7.5 mm, calibration of 4.1mm at T11-T12 and in the lumbar region it is about 4-7mm. This space is much greater in volume when compared to the corresponding subarachnoid space at the same level. It takes about 0.3 ml of a local anaesthetic to block a spinal segment in the subarachnoid space while about 1.5-2 ml of local anaesthetic is required to produce an epidural block.

The cervical, thoracic, lumbar and sacral spaces form the divisions of the epidural space. They are defined according to their margins. The membranes of

medulla spinalis and dura mater lining the periosteum fuses from the foramen magnum till the lower border of vertebrae prominens to form the cervical epidural space. While from the lower boundary of C7 to the upper boundary of L1 constitutes the thoracic epidural space. The extension of the lumbar epidural space is from the lower border of L1 vertebra till the upper border of S1 vertebra. The upper margin of S1 to sacrococcygeal membrane demarks the sacral epidural space.

The inbuilt negative pressure within the epidural space limits its demarcation. There are two theories explaining this negative pressure. The Cone Theory states that the needle introduced into the epidural space depresses the dura, consequently creating a larger epidural space. It is thus considered an artefact caused by the indentation of the dura by the advancing needle. Telford and Holloway[2] demonstrated that epidural space pressures were always positive and negative pressures were only recorded when there is tenting of the dura with a relatively blunt needle. The Transmission Theory considers that the vacuum in the epidural space is caused by the transmission of the intrapleural negative pressure via the intervertebral foramina to the peridural space. This negative pressure is greatest at points of firm attachment and in the thoracic region. It is less in the lumbar region and least or absent in the sacral area. Gil et al.[3] ,2008 demonstrated that specifically in the thoracic epidural space, particularly in the sitting posture, there is development of more negative

pressure than in the lateral recumbent position. This therefore clearly shows that when the hanging drop technique is used to identify the epidural space, sitting position defines the epidural space more distinctly.

The constituents of the epidural space

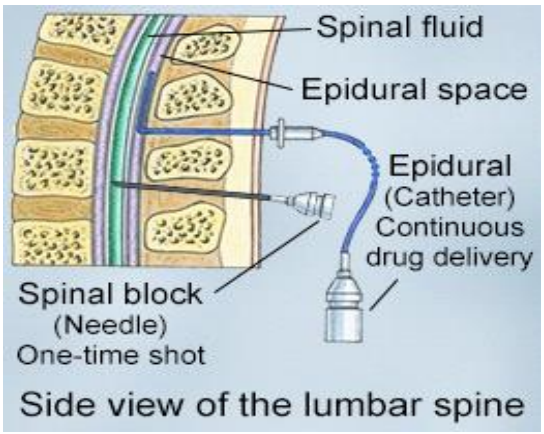
Semi-liquid fat, epidural arteries, loose areolar connective tissue, lymphatic channels, the nerve roots of the spinal cord, and a vast venous plexus are contained in the epidural space. Hogan[4], 1998 proved that the contents of the epidural space are segregated by distinct zones where the vertebral canal comes in contact with the duramater and arranged in a circumferential series of compartments discontinuously.

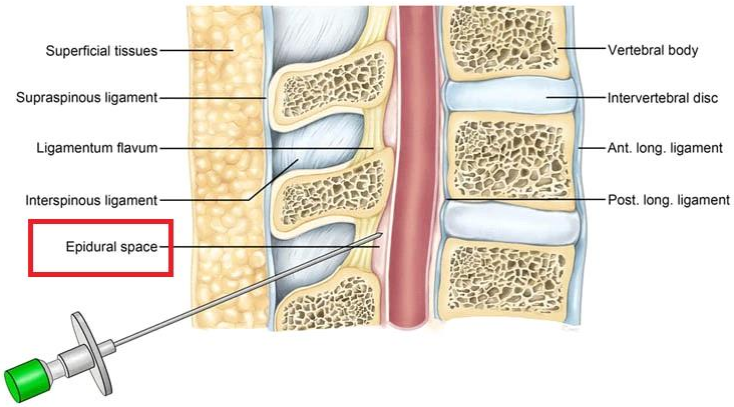
Semi-liquid Fat

There has been numerous studies about the fat distribution in the epidural space. A study carried out by Reina et al[5]., 2006 proved that there is a predictable pattern of distribution of epidural fat abundantly within the spinal canal. Adipocytes are also numerous in the duramater, sleeving the spinal nerve roots. There is no embedment of fat cells within the laminas of the dural sac which form the dura mater. The pulsatile movements of the dural sac is buffered by these adipocytes in the extradural space which also serves to protect the neural elements. Thus this creation of a lipophilic reservoir facilitates smooth movements during flexion and extension of the spine allowing the dural sac to slide over the periosteum of the vertebrae. Reina et al[5]., 2006 showed the

continuous metameric pattern of arrangement of the epidural fat in human adults. The storehouse of fat in the dural sleeves could act as reservoir of drugs thus leads to greater effect on nerve roots compared to the drugs stored in epidural fat. This is due to the proportionately larger concentration of fat near the nerve roots, and their closer proximity.

Reina et al.[5], 2009 also highlighted that the pathologies altering the distribution or fat content changes the absorption or distribution of drugs administered in the epidural space.





Anatomy of Epidural Space

Applied Anatomy and Clinical Importance of the Epidural Space

The distribution of adipocytes is predominantly on the dorsal region of the space. It is connected via a vascular pedicle to the middle of the ligamentum flavum and arranged in triangular capsular shapes. This peculiarity of the adipocyte arrangement contributes to the resistance during epidural catheter insertion and for the pharmacokinetics of local anaesthetics and drugs injected into the space to act on the dorsal spinal nerve roots.

Lymphatic System

The lymphatic system contained within the epidural space act as scavengers by removing the foreign particles including microbes from the epidural and subarachnoid spaces. The dural roots mainly harbour the lymphatics.

The Valveless Vertebral venous plexus

Domisse[6], 1975; Parkin and Harrison[7], 1985; Brockstein et al[8]., 1994 thoroughly studied the internal vertebral venous plexus and found them to be anchored within the epidural space. Mehl[9], 1986 claimed that this plexus of veins caused tapping of blood in the epidural needle. There are four longitudinal interconnecting vessels, two anterior and two posterior which contribute to the internal vertebral venous system. Williams et al[10]., 1989 on the contrary showed that the external vertebral plexus is made up of anterior and posterior plexus of

veins lying peripheral to the vertebrae. Being located anterior to the vertebral bodies the external vertebral venous system is related to the laminae, spinous processes, transverse processes and articular processes of the vertebrae respectively.

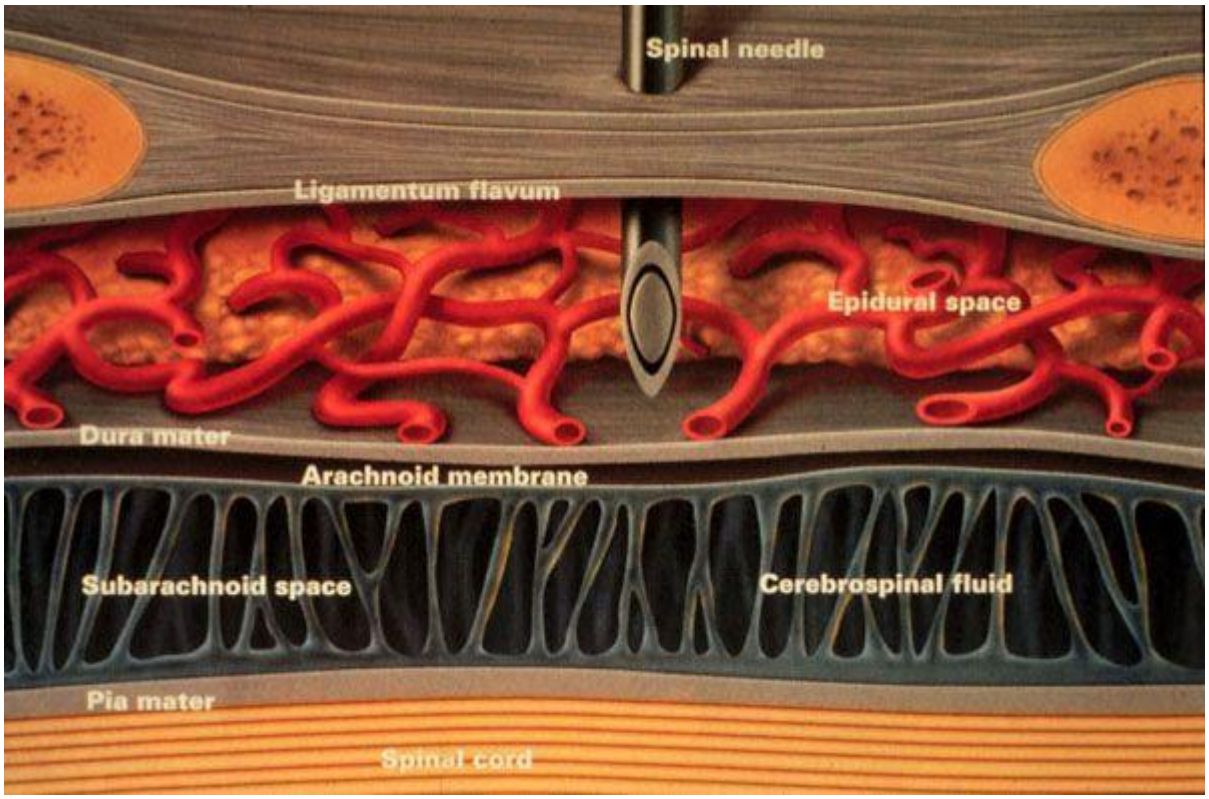
The segmental veins of the neck, the intercostal, azygos and lumbar veins form the communicating channels of this system. Batson's vertebral venous plexus is formed by the network of periosteal veins of the vertebral column, along with the internal and external vertebral plexuses. (Domisse[6], 1975). Being predominantly situated in the anterior and lateral portion of the epidural space, these veins unite with the azygous venous system finally. During conditions like ascites and pregnancy, increase in intrathoracic or intra-abdominal pressures is directly transmitted to this system as the entire system is valveless, leading to major congestion and enlargement of vessels within the spinal canal. A sparse quantity of fat circumference the epidural venous plexus.

A rich valveless venous plexus fills the anterior epidural space. The plexus makes important communications with the cerebral venous system namely, the sigmoid sinus, basilar veins, vertebral vein, occipital veins, and the azygous vein. The transmission of abdominal and thoracic cavity pressures to the epidural space is because of the linkage with the abdominal and thoracic venous system via the intervertebral foramina. The sacral venous plexus is formed by the connection of vertebral venous plexus with the iliac veins. There

is an increased risk of bleeding while securing the epidural needle or catheter when there is distension of the venous plexus during advanced stages of pregnancy, obstruction of inferior vena cava or abdominal cavity malignancies.

Arteries of the epidural space

The branches of the ilio-lumbar arteries forms the vascular supply to the lumbar epidural region. Advancement of the epidural needle does not injure these arteries as they are found laterally.



Epidural Space and its contents

Identifying the extradural space

Identifying the epidural space is a demanding technique and as anaesthesiologists it is of crucial importance. The first demonstration of this space was made by Dogliotti[11], 1933 about 83 years back. The functionality of the epidural analgesia depends upon the accuracy of detection of the epidural space. As the epidural needle is inserted in the midline, it pierces the skin, the subcutaneous tissue, the supraspinous, interspinous ligament and has to traverse the ligamentum flavum to reach the space. The depth of the epidural space is defined as the distance from overlying skin to the tip of the needle just penetrating into the epidural space (Lai et al.[12], 2005). In obese patients the depth is difficult to identify.

To improve the probability of success rate in identification of the peridural space, Ravi et al[13]., 2011 found out a correlation between the body mass index(BMI) and the depth of the epidural space This study showed that the depth of the epidural space increased significantly as the BMI increased. Based on linear regression analysis, the equation for depth of epidural space is

Depth (mm) = a + b (BMI).

Where a = 17.7966 and b = 0.9777.

Identification of the epidural space

Negative pressure contributes to the most traditional method of spotting the epidural space. In order to minimize the associated complications, any technique identifying the epidural space should be simple, safe and reliable.

Loss of resistance (LOR) is one of the most reliable technique in identifying the extradural space. In this method a glass or plastic syringe is filled with either air or saline or local anaesthetic and advanced from the skin by applying a continuous or intermittent pressure on the piston. The point where it becomes possible to inject through the syringe marks the loss of resistance. As the injection through the ligamentum flavum is not possible, this technique always works better. The syringe may contain air or saline. Since air has a greater compressibility than saline or local anaesthetic, the specifications of the technique are different whereas it carries the same principles.

The identification of the epidural space with LOR to lidocaine or air plus lidocaine has minimal chance of puncturing the dura as compared to air alone and technique wise also it is potentially difficult. Evron et al[14]., 2004 has stated that sequential use of air and lidocaine has no benefits over lidocaine alone . The complications associated with this technique has been studied. Nay et al[15]., 1993 proved that paraplegia could result from LOR to air, the development of pneumocephalus was highlighted by Nafiu & Bullough[16], 2007. Okutomi &

Hoka[17], 1998 insisted the association between LOR to saline and the dilution of the injected local anaesthetic.

Hanging Drop Sign: A small drop of sterile distilled water is placed on the hub of the needle after it is introduced to the level of resistance indicating the beginning of the ligamentum flavum. When the needle is advanced through the yellow fibrous tissue, this drop will be sucked into the epidural space. This is called the "sign of the drop".

Capillary Tube Method: Odom developed an improved method for detecting the epidural space where he devised a small capillary tube filled with sterile saline in which one or two bubbles of air were placed. These acted as a meniscus. As soon as the needle entered the epidural space, the saline was sucked in and the air bubbles could be seen advancing into the space.

Michel & Lawes[18], 1991 devised a new technique called modified drip method to identify the epidural space. In this trial, an infusion of saline was filled in the tubing and attached to the hub of the epidural needle and the distal 40 cm was left full of air. In a majority of cases, precise identification of the extradural space was accomplished in a petty time. In contrast to the manual loss of resistance technique and hanging drop method, this study showed a clear edge.

Lin et al[19]., 2002 observed a novel approach called as "membrane in syringe" with two distinct benefits. A syringe is divided into two halves by

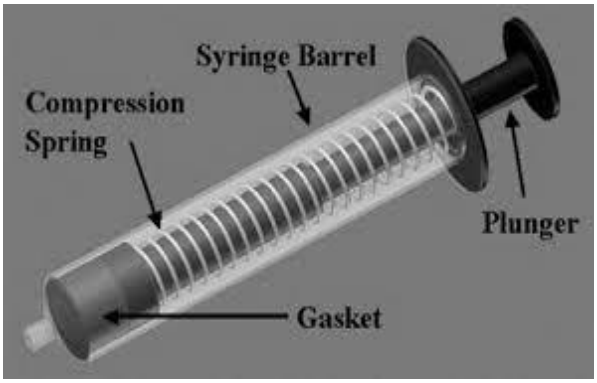
keeping a plastic membrane in the middle. The distal nozzle end of the plastic syringe is filled with saline. The other hollow cylindrical portion of the syringe is closed with the plunger. The air compartment is the space enclosed between the rubber plunger and the plastic membrane. First and foremost advantage of this technique is that air entrance is prohibited without hampering the feel of compressibility. Wrinkling of the plastic membrane and injection of saline indicates the entrance into the epidural space is the second benefit of this technique.

The Macintosh epidural balloon serves as a simple method in identifying the extradural space. A small balloon is filled with 2 to 3 ml of air and lodged on to a glass adapter attached to the epidural needle when it reaches the ligamentum flavum. The collapse of the balloon signifies the epidural space penetrance. Fyneface-Ogan & Mato[20], 2008 weighed the identification characteristics of both epidural balloon and loss of resistance technique and ascertained that the space could be more swiftly detected at the first attempt by the epidural balloon although the cost factor plays a role.

Samada et al[21]., 2011 invented an optimal pressure producing loss of resistance device called the Epidrum for localising the epidural space. The operation of the device is at a high pressure set to be liberated into the extradural space, taking care not to cause premature leakage into the patient's tissues. An extremely thin diaphragm situated at the top of the Epidrum acts as

the meniscus of a manometer to create an optimal pressure. This facilitates the operator to identify the position of the needle tip with help of the diaphragm's signal. Epidrum has the following advantages

- Shorter learning curve as the procedure is comparatively simple. When the trainee is performing the procedure the trainer can monitor the diaphragm signal.
- It is an effective, trustworthy and harmless procedure.
- Post dural puncture headache and the risk of epidural haematoma formation could be drastically prevented by using a smaller needle
- A visual endpoint is offered.
- False positive errors could be minimized by using an optimized, low and constant pressure
- Dural tap can be easily seen by the draining cerebrospinal fluid



Loss of Resistance Syringe and its Technique

HISTORY

- **Soresi** was the first person to perform Combined Spinal Epidural technique in 1937.
- **Cerelaru** used separate spaces for each component in 1979.
- **Brownridge** in 1981 advised the use of CSE in caesarean section.
- **Carrie** in 1984 described needle through needle technique.
- **Dr**. **Morgan** in 1993 introduced CSEA (combined spinal epidural analgesia) for labour – walking epidurals.

EQUIPMENTS REQUIRED:

EPIDURAL NEEDLE:

The Epidural needle most commonly used is 16G or 18G Tuohy needle with bent tip with 8 cm/10 cm long shaft. A radical improvement suggested by

Huber resulted in bending the point and placing the bore opening on the side of the point. This is called Tuohy-Huber point needle with a blunt leading edge and a lateral opening at the tip. The Epidural catheter is 16G or 18G with single hole at the end or closed end with side holes at multiple levels. A 0.2 micrometer filter at proximal end is to prevent contamination by bacteria and injection of particulate matter through the catheter. Other types of epidural needles are Crawford Point Needle and Hustead Needle.

SPINAL NEEDLE:

Quincke Babcock's needle 23G - 27G is most commonly used standard spinal needle. It has a small hub and a sharp point with a medium length cutting bevel. A stylet is fitted matching the bevelled tip to the cannula point. The hub is designed with a Luer-Lock connector. Other types are fine gauge needles (24G -27G) with a pencil point tip (Sprotte or Whitacre). The combined spinal epidural kit consists of 8cm Tuohy needle with 120 mm spinal needle or 10 cm Tuohy needle with 150 mm spinal needle. Optimum protrusion of spinal needle in the kit is 1.7 cm.

CSE TECHNIQUES:

- **SINGLE PASS :**

  It was first described by **Soresi** in 1931. In this technique needle introduced into the epidural space injects some quantity of local

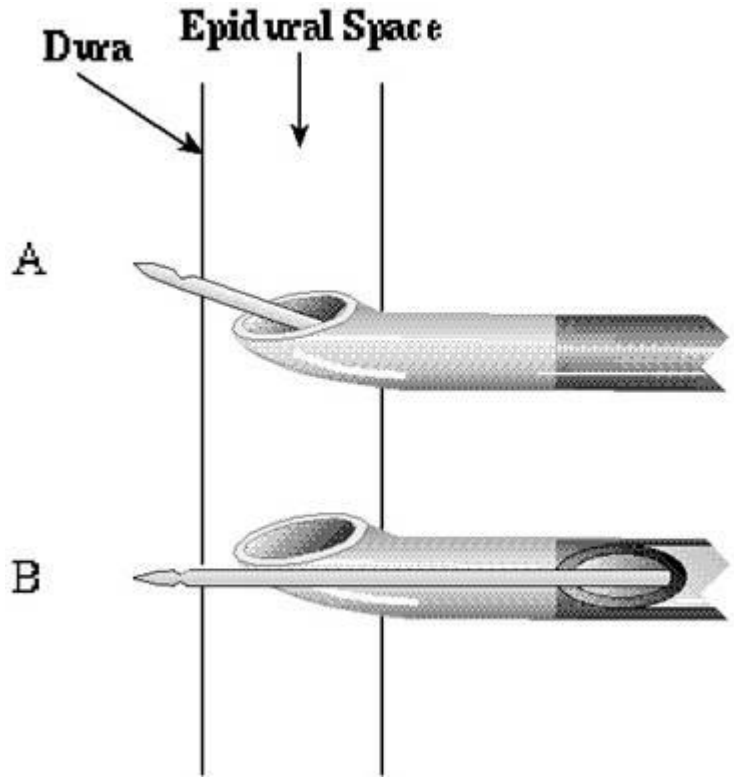
anaesthetic and then advanced further into the subarachnoid cavity where subsequent dose of local anaesthetic is deposited. It is not used nowadays and there is no longevity of the block.

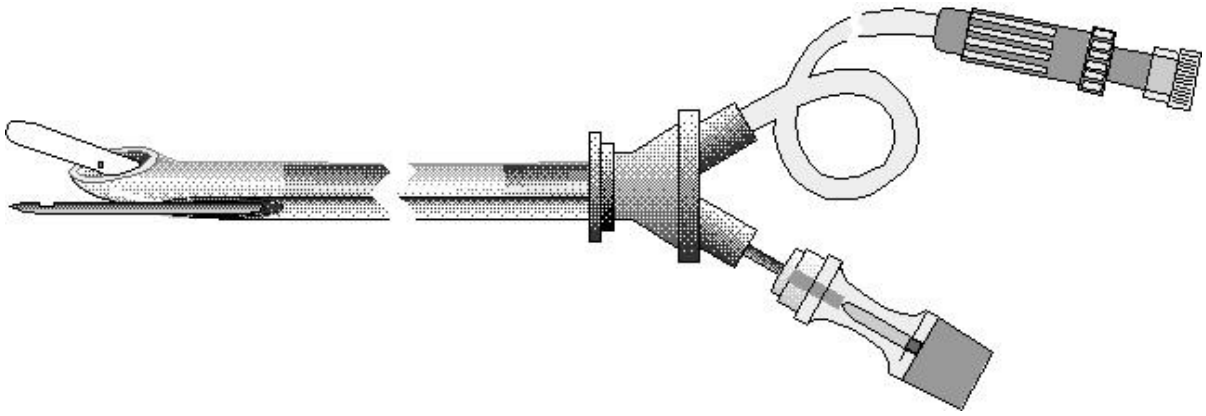
- **NEEDLE THROUGH NEEDLE:**

16 G or 18 G epidural needle is used to identify the epidural space. Spinal needle of size 24G to 27G is then introduced via the epidural needle, till dural piercement is felt. Spinal needle stylet is then removed. Cerebrospinal fluid needs to be visualized in the hub of the spinal needle. Injection of local anaesthetic agent is done. Spinal needle is taken out and about 3.5 cm of the epidural catheter is placed inside. Epidural catheter is secured with sterile tapes and used to prolong pain relief once the spinal anaesthesia wears off.

- **NEEDLE THROUGH NEEDLE (BACKEYE+) :**

Epidural needles, with back-eye on the curve, specially designed for allowing spinal needle introduction in a straight line, tip coming out through the back-eye, entering the subarachnoid space. The epidural catheter then travels along the curved part of the epidural needle and the tip is positioned cephalad.





Needle through Needle Technique

- **LOCKING NEEDLE THROUGH NEEDLE:**

It has locking device to stabilize the spinal needle with the epidural needle, after identifying the epidural space, which provides stability to the spinal needle.

- **SEPARATE NEEDLES THROUGH SEPARATE INTERSPACES:**

Epidural catheter and spinal needle are introduced separately at two different intervertebral spaces. Possibility of catheter injury by the spinal needle tip cannot be ruled out.

- **SEPARATE NEEDLES THROUGH SAME INTERSPACES :**

Epidural catheter is placed first followed by spinal needle insertion and then the subarachnoid drug administration. Provides good patient satisfaction.

- **COMBINED NEEDLE :**

This avoids the friction, supposed to occur while using needle through needle technique and separates the epidural and spinal components.

- **DUAL CATHETER TECHNIQUE :**

Spinal and epidural catheterization can be done separately. They have the possibility of catheter entanglement, cauda equina syndrome and accidental subarachnoid injection of high volume of drugs, mistaking spinal for epidural catheter that might result in total spinal anaesthesia.

SPINAL ANAESTHESIA ALONE

ADVANTAGES:

- Rapid onset
- High reliability than epidural
- Dose requirement reduced, prevents toxicity
- End point of needle placement is definite.

DISADVANTAGES:

- No options to extend the blockade.
- As dura is deliberately breached, the risk of postdural puncture headache is high.

EPIDURAL ANAESTHESIA ALONE

ADVANTAGES:

- Used widely
- Familiarity of the technique
- Epidural catheter allows top up doses to produce alteration or prolongation of the blockade
- Hypotension occurs slowly when compared to subarachanoid blockade.

- Postdural puncture headache is uncommon, unless accidental dural puncture occurs.

DISADVANTAGES:

- Slow onset
- Sometimes asymmetrical or patchy
- Huge volume of local anaesthetic agents needed
- Certain spinal nerve roots could not be blocked.

COMBINED SPINAL EPIDURAL ANAESTHESIA CAN THUS PRODUCE…

- Rapid induction of anaesthesia
- The quality of pain relief is better
- Low dose of local anaesthesia required
- Epidural catheter can prolong and optimize spinal block

COMPLICATIONS OF CSE TECHNIQUE:

- Technically difficult
- Extensive blockade

This may be due to

- Bolus of epidural local anaesthetic agent may act on the spinal nerves.
- The epidural drugs may cross the dural membrane
- Accidental migration of catheter tip to the intrathecal cavity.

  -Epidural bolus of anesthetic agent can extend the intrathecally administered drug, only while the subarachanoid blockade is developing (13 minutes)

- Postdural puncture headache
- Meningitis
- Neurological sequalae is rare.

COMBINED SPINAL EPIDURAL KIT

RATIONALE BEHIND EPIDURAL VOLUME EXTENSION

Epidural volume extension (EVE) is an alteration of the CSE technique where normal saline injected into the peridural space after subarachnoid injection of hyperbaric bupivacaine. This is aimed at rapidly increasing the sensory level obtained spinally by causing thecal compression to ascend the intrathecal drug.

EVE is a unique technique for regional anaesthesia which offers reliability and rapidity of spinal anaesthesia along with the flexibility of epidural anaesthesia. Desired degree of surgical anaesthesia is achieved with a small dose of local anaesthetic which prevents adverse hemodynamic effects seen with the conventional doses. It avoids the disadvantages of general anaesthesia in patients with high cardiac risk by avoiding the cardiodepressant drugs.

We could titrate the level of anaesthesia, vary the intensity of block, extend the duration of anaesthesia and also deliver postoperative analgesia. Provides early ambulation and is also cost effective. EVE is a novel technique which is increasingly being used nowadays for orthopaedic, gynaecological and urological procedures thus commanding a unique place in the anaesthesiologist’s armamentarium.

ORTHOPAEDICS AND REGIONAL ANAESTHESIA

A maximum proportion of the patients coming for orthopaedic surgeries are middle aged and elderly. As the age advances, there is a constant deterioration in the functional reserve thus not sparing any organ system. Accordingly, the response of the elderly people to surgery and anaesthesia are varied.

The response of the geriatric patients to stress and illness is unpredictable due to the coexistence of numerous major medical conditions. These patients present commonly with alterations in the respiratory mechanics with impaired efficiency of gas exchange. Structural alterations in the upper and lower airways occur. Cardiovascular and autonomic aging leads to an unstable blood pressure and hypokinesia with lower ejection fraction. Diabetes mellitus, coronary artery disease, ischemic cardiomyopathy, moderate left ventricular dysfunction, severe right ventricular dysfunction, severe pulmonary artery hypertension are commonly presented to the orthopaedic department following trauma.

The options that could be pondered broadly include spinal or general anaesthesia. EVE has emerged as a resolving technique for all undesirable elderly changes. It has significant dose sparing effect providing the required level of anaesthesia and analgesia without compromising the hemodynamic profile of the patient. It has offered the advantage of regional and general anaesthesia at the same time avoiding the undesirable side effects of both the

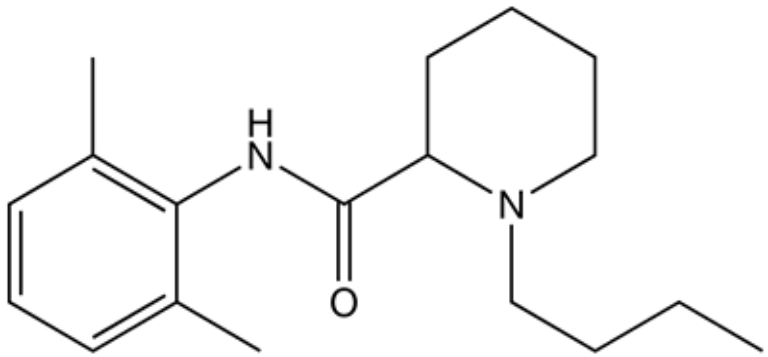
techniques. It also provides a backup in case spinal anaesthesia fails. It offers a clear edge over general anaesthesia eliminating airway manipulation and the accompanying stress response which would adversely affect the patient's cardiovascular status. It alleviates the negative inotropic effects of anaesthetic agents and the adverse effects on the venous return due to positive pressure ventilation.

The mild vasodilatation achieved by subarachnoid block by EVE's technique is found to be advantageous in patients with isolated left ventricular dysfunction. Thus EVE in CSE technique is highly efficacious well-tailored approach with careful fluid administration under the guidance of intensive monitoring helps to achieve our anaesthetic aim.

PHARMACOLOGY OF BUPIVACAINE

Bupivacaine is an amide local anaesthetic agent. It belongs to the homologous series of n-alkyl substituted pipecholyl xylidine group. It was first synthesized by **Ekenstam** in 1957 and was used clinically in 1963. It is produced for clinical use as a racemic mixture containing both 'S' and 'R' forms in equal proportion. It is supplied as a hydrochloride salt

CHEMICAL STRUCTURE:



1-butyl-n-(2, 6-dimethyl phenyl) -2-piperidine decarboxamide hydrochloride monohydrate.

PHYSIO – CHEMICAL PROFILE:

Molecular weight	-	288
pKa	-	8.1
Plasma protein binding	-	95%
Partition coefficient	-	28 (lipid solubility)

T ½	-	210 min
Clearance	-	8.3 l/min

MECHANISM OF ACTION:

Like all the other local anaesthetics, it inhibits Na channels. It decreases or prevents large transient increase in permeability of the cell membranes to Na ions that follows depolarization of the membrane and thereby blocks the nerve conduction. It also reduces the permeability of the resting nerve membrane to potassium ions as well as sodium ions and hence has got a stabilising action on all excitable membranes.

EFFECTS:

1) Local – nerve blockade
2) Regional – pain, temperature, touch, motor power and vasomotor tone supplied by the nerves are blocked.
3) Systemic – effects due to systemic absorption or accidental intravenous administration.

It is 4 times more potent than lignocaine but the onset of action is slower. The duration of action is longer. Sensory block is more marked than the motor block.

SYSTEMIC EFFECTS:

Central Nervous System:

Can produce circumoral numbness, metallic taste, tinnitus, light headedness, dizziness, confusion, slurred speech, convulsions

Cardiovascular System:

Depresses automaticity and contractility of the heart and slows down the conduction of the cardiac action potential as there is prolongation of PR and QR intervals on ECG. Re-entrant phenomenon and ventricular arrhythmias may occur. All these results mostly from high lipid solubility. R-enantiomer is more toxic than S-enantiomer. Pregnancy increases cardiotoxic effects of bupivacaine

KINETICS:

- Rapidly absorbed from the site of injection
- Peak systemic concentration – 5 to 30 minutes after administration
- Duration of action – 360 to 720 minutes
- Metabolism in liver – dealkylation to pipecoloxylidine, aromatic hydroxylation
- Excretion – 5% by kidney as unchanged drug and rest as metabolites

PREPARATION:

- 0.25%, 0.5% solutions in 10, 20 ml vials, respectively
- 5mg/ml (0.5%) bupivacaine with 80 mg dextrose (to increase baricity) in 4 ml ampoules for subarachnoid injection (baricity – 1.0207)

USES:

- Central neuraxial blocks
- For local infiltration subcutaneously
- Peripheral nerve blockade

SIDE EFFECTS:

Bupivacaine exhibits selective cardiotoxicity. It is due to its lipophilicity and blockade of cardiac sodium channels. Accidental intravenous injection precipitates hypotension, cardiac dysrhythmias like sinus tachycardia, supraventricular tachycardia, atrioventricular heart block, ventricular tachycardia, premature ventricular contractions, wide QRS complexes and ST - T wave changes.

CONTRAINDICATIONS:

- Known hypersensitivity to amide local anaesthetics
- Intravenous regional anaesthesia (IVRA)

MAXIMAL DOSE:

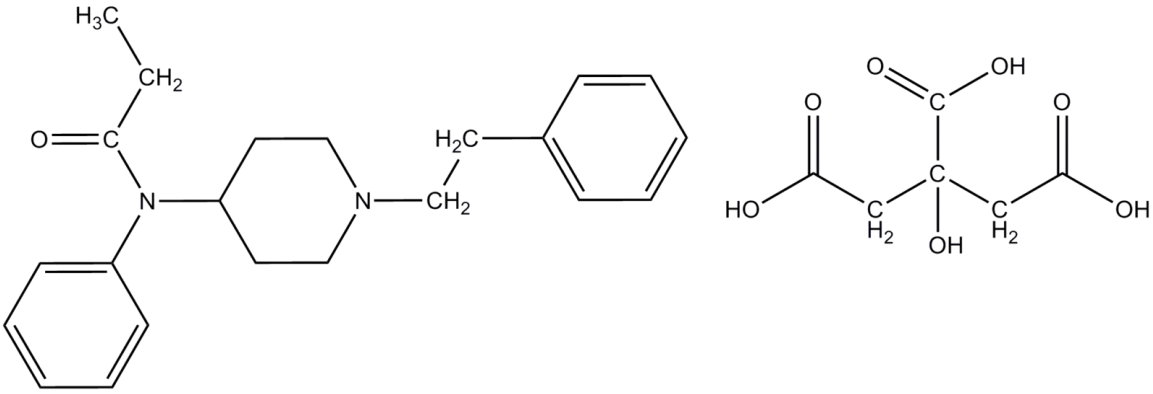
3 mg/kg body weight and the strength used is 0.25 – 0.75% with or without adrenaline (1:200000 or 1:400000). Adrenaline does not prolong its effect, but reduces its toxicity.

BUPIVACAINE VIAL

PHARMACOLOGY OF FENTANYL

Fentanyl is a phenylpiperidine derivative synthetic opioid agonist that is structurally related to meperidine. As an analgesic, fentanyl is 75 to 125 times more potent than morphine.

CHEMICAL STRUCTURE



Fentanyl Citrate

Propanamide, N-phenyl-N-[1-(2-phenylethyl)-4-piperidinyl]-, 2-hydroxy-1, 2, 3-propanetricarboxylate (1 : 1)

PHYSIOCHEMICAL PROFILE

Molecular weight	- 286
pKa	- 8.4
Plasma protein binding	- 79-87%
Octanol water partition coefficient	- 717 (highly lipid soluble)
T ½	- 141-853 mins
Clearance	- 13 ml/kg/min

MECHANISM OF ACTION

Fentanyl citrate is a highly selective mu opioid receptor agonist which is specifically involved in the mediation of analgesia. It decreases the membrane excitability by inhibiting the pre- and post-synaptic responses. It interacts with the presynaptic Gi protein receptor leading to the hyperpolarisation of the cell membrane by increasing the potassium conductance. Inhibition of adenylate cyclase decreases the production of cyclic adenosine monophosphate and closure of voltage sensitive calcium channels.

SYSTEMIC EFFECTS

CARDIOVASCULAR

Bradycardia is more prominent due to depression of carotid sinus baroreceptor reflex control of heart rate. It obtunds the cardiovascular responses to laryngoscopy and intubation. Allergic reactions are rare.

RESPIRATORY

Persistent or recurrent respiratory depression causes a decrease in tidal volume and respiratory rate. It diminishes the ventilatory response to hypoxia and hypercarbia. Chest wall rigidity (the wooden chest phenomenon) may occur due to the effect on mu receptors located on the GABA-ergic interneurons. It is a potent antitussive agent and bronchospasm is rare due to minimal histamine release.

CENTRAL NERVOUS SYSTEM

It is a more potent analgesic than morphine with little hypnotic or sedative activity. Miosis occurs as a result of stimulation of Edinger Westphal nucleus. Myoclonus secondary to the depression of inhibitory neurons produces a clinical picture of seizure activity in the absence of EEG changes. In doses exceeding 30 micrograms/kg i.v produces changes in the somatosensory evoked potentials. It is associated with modest increase in the intracranial pressure when administered to head injury patients.

OTHERS

It decreases the gastrointestinal motility, decreases the gastric acid secretion and causes spasm of sphincter of Oddi. It increases the tone of ureters, bladder detrusor muscle and vesicular sphincter.

KINETICS

Administered intravenously, it has a more rapid onset and shorter duration of action due to greater lipid solubility and faster redistribution.75% of the initial dose undergoes first pass pulmonary uptake that limits the systemic distribution. Continuous i.v infusion saturates the inactive tissue sites like fat and skeletal muscles. Metabolized by N-demethylation to norfentanyl, hydroxypropionyl-fentanyl and hydroxypropionyl-norfentanyl. Longer elimination half time is because of larger volume of distribution and reuptake

from inactive tissues. Substrate for cytochrome P450. 10% is excreted in urine unchanged and rest as metabolites.

PREPARATIONS

- 2 ml ampoule injections containing 50 micrograms per ml of fentanyl citrate.
- As transdermal patches delivering 75-100 micrograms / hour
- Oral transmucosal fentanyl lozenges mounted on a handle delivering 5-20 micrograms per kg.
- As fentanyl hydrochloride in an iontophoretic transdermal system.

USES

- Provides analgesic component in general anesthesia
- In combination with a major tranquilizer for neuroleptanalgesia
- Profound labour analgesia
- Agent for patient controlled analgesia
- In premedication and palliative care.

TOXICITY / SIDE EFFECTS

- Post-operative respiratory depression due to secondary peak in plasma levels as fentanyl is absorbed from small intestine and eluted from muscles.

- Nausea, vomiting and dependence may complicate the use of this drug.

FENTANYL CITRATE AMPOULE

REVIEW OF LITERATURE

Lew et al[22] evaluated the effectiveness of epidural volume extension in 62 gravid females prepared for elective caesarean section (n=31) by allocating them into two groups. The first group received combination of spinal and epidural anaesthesia with 5mg of 0.5% hyperbaric bupivacaine followed by 6 ml saline for epidural volume extension and the second group was provided with spinal anaesthesia with a dose of 9mg of 0.5% hyperbaric bupivacaine. He compared the sensory and motor block profile and also the hemodynamic status of the parturients. They proposed that patients in the EVE group showed a quicker motor recovery to modified Bromage scale 0 when matched with those who received spinal anaesthesia only. Hence they summarised that combined spinal epidural with EVE reduced the requirement of anaesthetic dose needed by as much as 55%. This study also justified the fact that CSE with epidural volume extension is associated with rapid motor recovery leading to a shorter recovery room stay and at the same time providing adequate anaesthesia for the surgery.

Salman et al[23] conducted his study in three groups of full term pregnant females with 37-42 weeks of gestational age planned for elective caesarean section. Group 1 consisted of 48 females who were placed in the right lateral recumbent position and they were given spinal anaesthesia with 27G Quincke needle. Patients received single dose of 0.5% levobupivacaine with 20

micrograms of fentanyl and the dosage was determined according to their heights.

- Patients with height < 160 cm were given 10 mg of the drug
- Patients with height 161 - 164 cm were given 12 mg of the drug
- Patients with height 165 - 169 cm were given 14mg of the drug
- Patients with height > or equal to 170 cm were given 15mg of levobupivacaine.

In the second group, 5ml of saline was given as epidural volume extension in addition to the spinal dosage of drug as described above. Group 3 patients were anaesthetised with CSE with 5 ml of 0.5% levobupivacaine as epidural volume extension respectively. From this study, it was drawn that adequate and rapid motor and sensory block with a faster onset, higher sensory level and longer duration was produced in group 2 and 3 and these effects were more significant in the third group.

Kaur and Jayant et al[24] randomised 105 females between the age group of 25 and 40 years of ASA physical status 1 and 2 planned for caesarean section into 3 groups of 35 each. Group B7 were anaesthetised with 7 mg of 0.5% hyperbaric bupivacaine. Group B7- EVE were given 7mg of 0.5% hyperbaric bupivacaine proceeded by 10 ml of saline in the epidural catheter 5 minutes later and Group B10 were spinal anaesthetised with 10 mg of 0.5% hyperbaric

bupivacaine without epidural volume extension. All the three groups also received 25 micrograms of intrathecal fentanyl as an additive. This lead to a conclusion that sufficient anaesthesia with quick motor recovery could result from epidural volume extension when spinal and epidural anaesthesia are combined.

Vanhelder T et al[25] studied the role of combined spinal epidural anaesthesia in managing parturients with valvular heart defects. They have presented a case of successful anaesthetic management of a parturient with moderate mitral stenosis and aortic insufficiency. They concluded that prudently planned regional anaesthetic technique (CSEA) was safely used for both labour and caesarean section in parturients with valvular heart diseases.

Asha Tyagi and colleagues[26] conducted a prospective sequential allocation study in adult males between the age group of 18 and 60 years belonging to physical status 1 and 2 scheduled for lower limb surgeries under combined spinal epidural anaesthesia to determine the maximum effective volume of normal saline for epidural volume extension. An inadequate level was defined as lower than T10 at 10 mins after the intrathecal injection with 10 mg of hyperbaric bupivacaine with no ascent for two consecutive readings taken 2 mins apart. The EVE was performed with normal saline injected through epidural catheter and was considered successful if the level of sensory block increased by two or more dermatomal segments within 5 mins of the injection.

The volume of normal saline for EVE was decided by using up and down method with the first patient receiving 10 ml and a dosing interval of 1 ml in subsequent patients. The minimum effective volume with 95% confidence interval was calculated using Dixon and Massey's formula. They concluded that the minimum effective volume of normal saline to raise the level of sensory block by two or more dermatomal segments within 5 mins of EVE is 7.4 ml (95% confidence interval 5.5 – 9.9 ml).

Gokce et al[27] enumerated the importance of the volume effect and migration of the spinal anaesthetic drug produced by the epidural injection of 10 ml of normal saline soon after the administration of intrathecal bupivacaine. He emphasised that there is an increase in the cephalad extent of the sensory block.

Takiguchi et al[28] carried out a myelographic study where he observed the "thecal compression" proceeding epidural volume extension. He selected a group of healthy adult volunteers for whom contrast medium was administered intrathecally and he positioned them 45 degrees upright. When 5 ml aliquots of normal saline was injected subsequently into the epidural space, they visualised the ascent of the contrast medium level in the subarachnoid space. They also showed 40% deduction in the diameter of subarachnoid space following the first aliquot of normal saline and 25% deduction soon after the second aliquot. With the third and fourth aliquots, the diameter of subarachnoid space decreased further; but the maximum reduction occurred after the first epidural injection.

They came to a proposal that the degree of thecal compression is directly proportional to the volume injected into epidural space, with larger epidural volumes producing greater compression.

Loubert and colleagues[29] chose 90 pregnant patients undergoing elective caesarean section randomly and segregated them into three groups of 30 each. Group B 7.5 were given 7.5 mg of 0.5% hyperbaric bupivacaine spinally. Group B 7.5-EVE were spinally anaesthetised with 7.5 mg of 0.5% hyperbaric bupivacaine followed by EVE with 5 ml of normal saline and 10 mg of 0.5% hyperbaric bupivacaine was given to group B 10. They embarked that median motor scores and Bromage scores were higher in group B10 and B7.5 comparing B 7.5 – EVE. They also highlighted that 5 ml of normal saline for EVE could not produce ample sensory anaesthesia and this volume was insufficient to overcome gravity.

Hideyuki Higuchi et al[30] experimented the sequalae of epidural saline injection on the cerebrospinal fluid volume and velocity waveform by magnetic resonance imaging study. He allocated three groups of patients randomly and injected saline into the epidural space via the catheter. First group of patients received 5 ml saline epidurally, 10 ml saline was administered to the second group, and the third group was given 15 ml of saline. Comparison of cerebrospinal fluid volume and velocity waveform before and after epidural injection was visualised by serial repeated images. Seven axial images at disc

levels from T11 – T12 to L5 – S1 were taken before injection and 1, 3, 5, 10, 15, 20, 25, 30 mins after saline injection. The dural area before and after saline injection was compared and contrasted. They summarised the mean reduction in the CSF volumes and it is as follows

- 2.0 +/- 1.0 ml reduction in the five ml group
- 4.4 +/- 1.4 ml reduction in the ten ml group
- 7.2 +/- 2.6 ml reduction in the fifteen ml group

After the epidural injection of saline, they drew a conclusion that the CSF velocity waveform did not synchronise with the cardiac cycle and it was crystal clear among the patients of 10 ml group. This proved the dependency of the injected saline volume on the reduction in CSF volume. There was no relationship between the CSF flow dynamics and dural sac compression which lasted for a minimum period of 30 mins during the study.

Akhilesh Kumar Tiwari et al[31] highlighted the efficiency of epidural volume extension technique in CSEA in patient of different specialities with compromised cardiac functional status. Study included patients with global hypokinesia with left ventricular dysfunction (EF < 30%), trauma patients with systemic illness like diabetes mellitus, coronary artery disease , ischemic cardiomyopathy, severe right ventricular dysfunction and severe pulmonary artery hypertension planned for knee amputation, primigravida at 36 weeks

gestation presenting with peripartum cardiomyopathy planned for elective caesarean section, and 23 yrs old primigravida diagnosed with Takayasu arteritis along with bilateral subclavian and renal artery involvement with dilated cardiomyopathy. All these patients underwent successful surgery by using EVE's technique using 1ml of 0.5% ropivacaine and 25 micrograms of fentanyl followed by 8 ml of normal saline through epidural catheter 5 mins after subarachnoid block. The novelty of this technique was recognized by the stable hemodynamic parameters and achievement of desired blockade.

AIM OF THE STUDY

To evaluate the effectiveness of epidural volume extension using 10 ml of 0.9 % saline in combined spinal epidural anaesthesia to perform adequate neuroaxial blockade using low dose of intrathecal hyperbaric bupivacaine in lower limb orthopaedic surgeries.

PRIMARY OBJECTIVES

- Level of maximum sensory blockade
- Time to reach maximum sensory blockade
- Two segment regression time of sensory blockade
- Time to reach maximum motor blockade
- Time to recover from motor blockade

SECONDARY OBJECTIVE

- Time at which the first rescue analgesia is given epidurally
- Blood pressure and heart rate variations are observed
- Top up doses of bupivacaine required

MATERIALS AND METHODS

PATIENT SELECTION

After getting approval from the Institutional Ethics Committee of Govt. Kilpauk Medical College and written informed consent from patients / relatives, 80 patients of ASA 1 and 2 who underwent elective lower limb orthopaedic surgeries in supine position at Govt. Kilpauk Medical College Hospital and Govt. Royapettah Hospital were enrolled in this study group.

INCLUSION CRITERIA

- Age above 40 years and below 70 years
- Height > 150 cm and < 170 cm
- Weight 40 – 75 kg
- Males and females.
- ASA physical status 1 and 2.
- Patients undergoing elective lower limb orthopedic surgeries in supine position
- Who have given valid informed consent

EXCLUSION CRITERIA

- ASA physical status 3 and 4
- Patients who refuse regional anaesthesia.
- Patients with an increase in intracranial pressure
- Intrinsic or idiopathic coagulopathy
- Skin or soft tissue infection at the proposed site of needle insertion
- Severe hypovolemia
- Pre-existing neurological disease like lower extremity peripheral neuropathy.
- Emergency orthopedic surgeries
- Orthopaedic surgeries not done in supine posture.
- Surgeries lasting for more than 3 hrs.
- Patients with known allergy to study drugs

MATERIALS

- Boyles machine with circle CO2 absorber circuit.
- 16 G or 18 G Tuohy epidural needle with 18 G or 20 G epidural catheter and LOR syringe
- 25 G or 23 G Quincke's Spinal needle
- Local anaesthetic 0.5% hyperbaric bupivacaine, Injection 2% lignocaine with adrenaline (1 in 200000)
- Loaded 5 ml syringe containing 30 mg of ephedrine and 2 ml syringe containing 1.2 mg of atropine.
- Mcintosh laryngoscope with blades 3 and 4
- Endotracheal tubes 7, 7.5 and 8 mm CETT
- Emergency drugs, intravenous fluids and other resuscitative equipments.
- Preloaded 10 ml syringe with normal saline.

GROUPS

Group A: Combined spinal epidural anaesthesia with epidural volume extension of saline (CSE-EVE).

Group B: Combined spinal epidural anaesthesia alone (CSE).

METHODOLOGY

This study was designed as a prospective randomised control study. Patients were preoperatively evaluated, clinically examined and proper investigations were done prior to assessment. Procedure was explained in detail and written consent was obtained. After ascertaining the inclusion criteria, preoperative investigations were recorded.

ANAESTHESIA PROCEDURE

After preparation of all requirements of both regional and general anaesthesia, CSE was performed under strict aseptic precautions with patient in sitting position at L2 – L3 or L3 - L4 interspace using low dose intrathecal hyperbaric bupivacaine 10 mg (2 ml of 0.5% bupivacaine) and 25 micrograms (0.5 ml) of fentanyl. Epidural was first performed using 16 G or 18 G Tuohy needle by loss of resistance to air technique and 18 G or 20 G epidural catheter was inserted in a cephalad direction 4 - 6 cm into epidural space and secured. Spinal anaesthesia was then performed using 25 G or 23 G Quincke's needle in a different interspace. Five minutes after performing the block, 10 ml of sterile preservative free 0.9 % normal saline was injected in the epidural space.

In the second group patients were anaesthetized using combined spinal epidural without epidural volume extension using the same technique and the same dose of intrathecal hyperbaric bupivacaine and fentanyl. An effective dose is defined as one that resulted in a sensory block height of T 10 level within 20

minutes of intrathecal injection with no epidural top up. Any episodes of hypotension (systolic blood pressure < 20% from baseline) was treated by administering titrated intravenous bolus of ephedrine 6 mg and intravenous fluids. Bradycardia (Heart rate < 25% from baseline) was treated with intravenous bolus of atropine 0.6 mg. When an ineffective blockade occurred during the study, surgery was carried out subsequently with epidural top up or converted to general anaesthesia. Post operatively patients were observed for any complications like postdural puncture headache, urinary retention and infections for 48 hours. The epidural catheter was removed thereafter.

Anaesthesia monitoring and parameters analysed:

Pulse rate, noninvasive blood pressure, pulse oximetry (SPO2), ECG, were recorded throughout the surgery. The level of maximum sensory blockade, time to reach maximum sensory blockade (min) and two segment regression time was determined by pinprick test. The time to reach maximum motor blockade (Bromage 3) and the time to recover from motor blockade (min) was also recorded. Motor blockade was assessed by Modified Bromage Scale.

Scale 0 - able to move the hip, knee and ankle

Scale 1 – unable to move the hip, able to move the knee and ankle

Scale 2 – unable to move the hip and knee, able to move the ankle

Scale 3 – unable to move the hip, knee and ankle

The blood pressure and heart rate changes were observed at various intervals (at the 5^{th}, 10^{th}, 15^{th}, 20^{th} min and then every fifteen minutes thereafter at the 35^{th}, 50^{th}, 65^{th} and 80^{th} min) of surgery. The top up doses of bupivacaine given through the epidural catheter in case of ineffective spinal anaesthesia and the requirement of ephedrine and atropine were also recorded which was the secondary outcome of the study.

Data Analysis

Descriptive statistics was done for all data and were reported in terms of mean values and percentages. Suitable statistical tests of comparison were done. Continuous variables were analysed with the unpaired t test.. Categorical variables were analysed with the Chi-Square Test and Fisher Exact Test. Statistical significance was taken as $P < 0.05$. The data was analysed using SPSS version 16 and Microsoft Excel 2007. Assuming that 80 percent as power of the study, minimum sample size required for the study was calculated to be 70.In our study 80 subjects were chosen.

Groups

Group	Intervention	Number
Group CSE - EVE	Combined spinal epidural with epidural volume extension	40
Group CSE	Combined spinal epidural	40

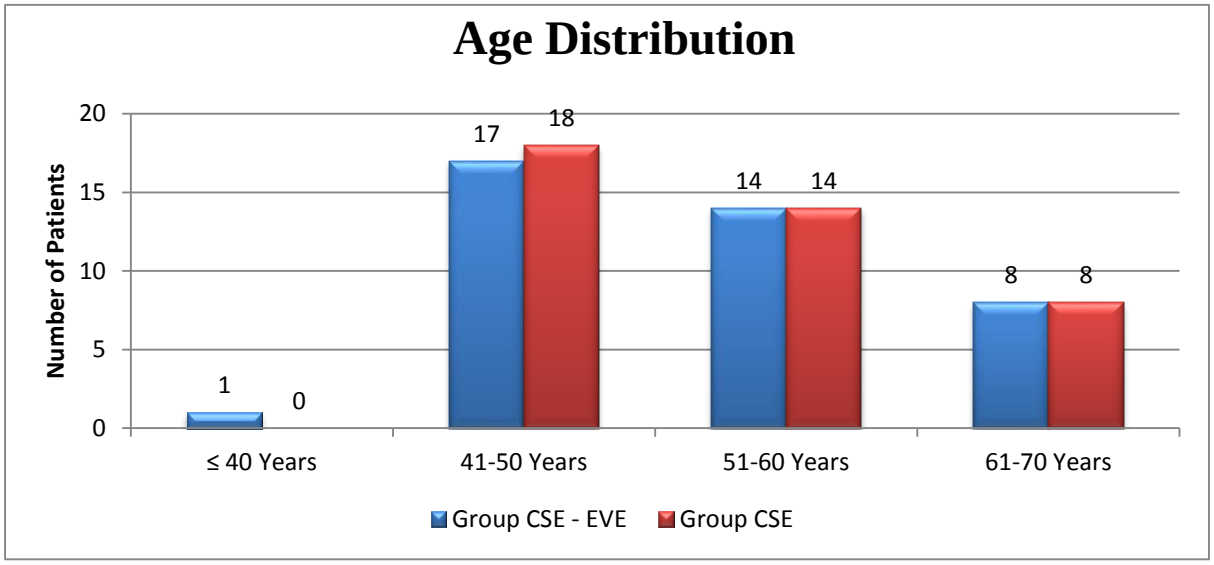
Null Hypothesis

Null Hypothesis : H0	Combined spinal epidural with epidural volume extension with normal saline is equal in effect to Combined spinal epidural in patients undergoing lower limb orthopedic surgeries using low dose of intrathecal hyperbaric bupivacaine
Alternate Hypothesis : H1	Combined spinal epidural with epidural volume extension with normal saline is superior in effect to Combined spinal epidural in patients undergoing lower limb orthopedic surgeries using low dose of intrathecal hyperbaric bupivacaine

OBSERVATION AND RESULTS

- A total of 80 patients of ASA- PS1 and PS2 were studied.
- Forty patients were enrolled into each of the two groups (A and B).
- There was no statistical significance between the two groups when the demographic parameters like age distribution, sex distribution, weight and height of the patients were compared.
- The comparison of parameters like, level of sensory block attained, two segment regression time, time for maximum sensory blockade to be achieved, time to achieve maximum motor blockade and the requirement of top up doses of bupivacaine was found to be statistically significant between the two groups.
- Blood pressure and heart rate changes were insignificant between the two groups.
- All the 80 patients underwent elective lower limb orthopaedic procedures done in supine position only.

Age

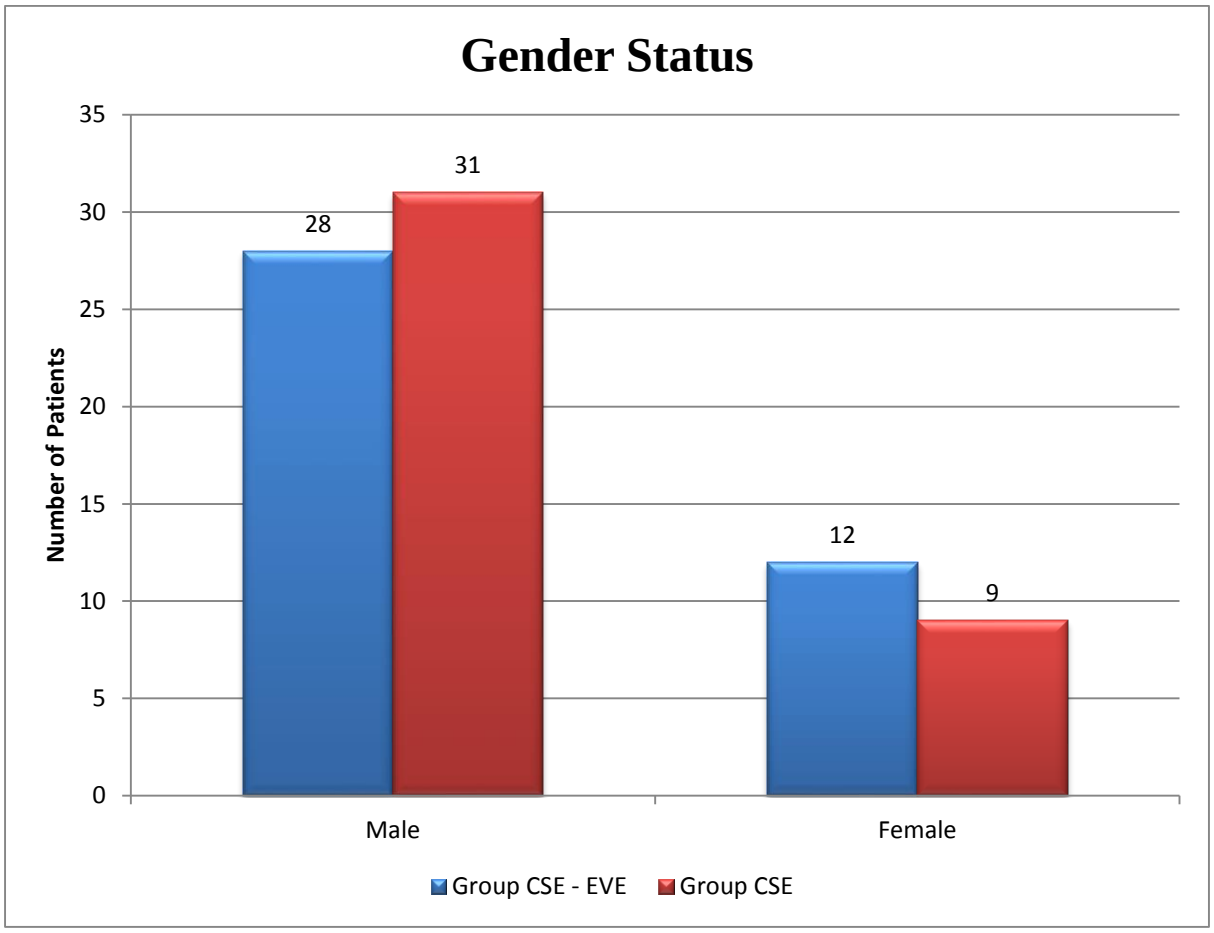


Age Distribution	Group CSE – EVE	%	Group CSE	%
≤ 40 Years	1	2.50	0	0.00
41-50 Years	17	42.50	18	45.00
51-60 Years	14	35.00	14	35.00
61-70 Years	8	20.00	8	20.00
Total	40	100	40	100

Age Distribution	Group CSE - EVE	Group CSE
N	40	40
Mean	53.13	53.15
SD	8.09	7.24
P value Unpaired t Test		0.9884

Among the patients undergoing lower limb orthopedic surgeries using low dose of intrathecal hyperbaric bupivacaine, there was no statistically significant difference in relation to age distribution between group CSE - EVE (mean=53.13, SD=8.09) and group CSE (mean=53.15, SD=7.24) with a p value of >0.05 as per unpaired t test. Therefore we fail to reject the null hypothesis that there is no difference in age distribution between the intervention groups.

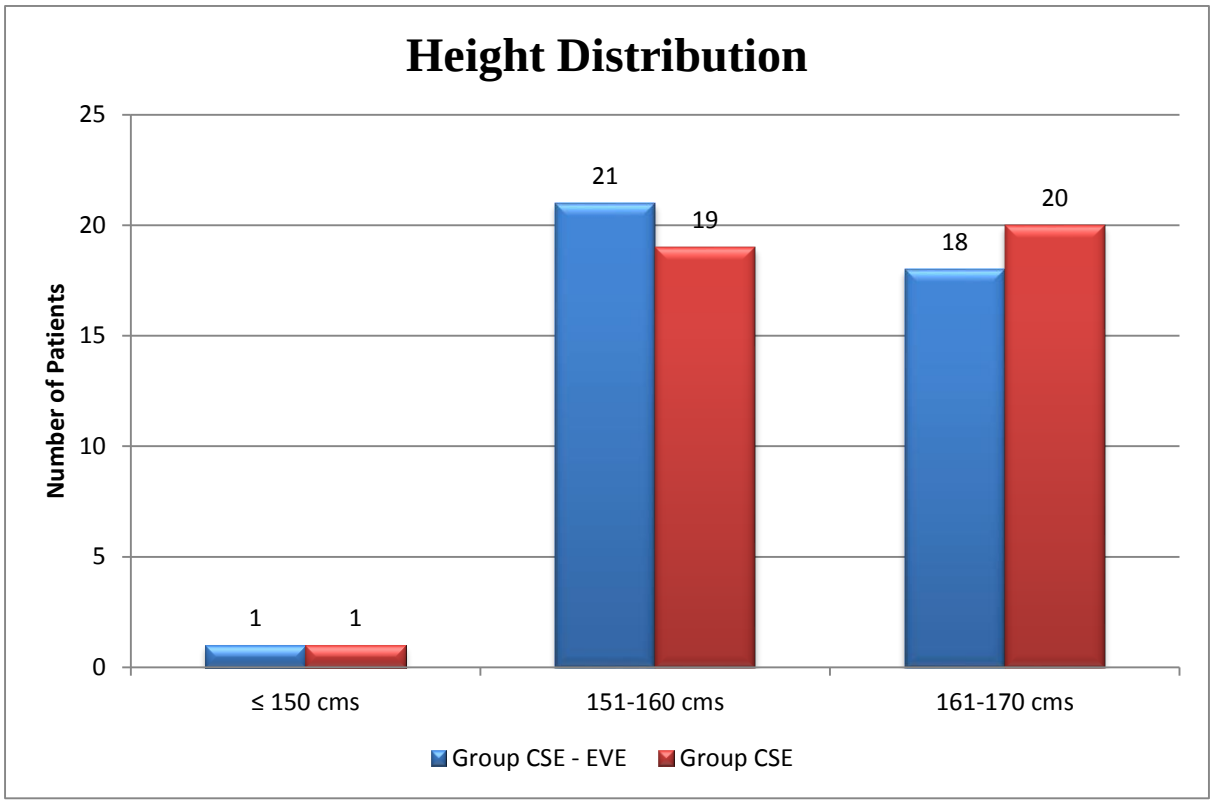
Gender



Gender Status	Group CSE - EVE	%	Group CSE	%
Male	28	70.00	31	77.50
Female	12	30.00	9	22.50
Total	40	100	40	100
P value Chi Squared Test			0.4459	

Among the patients undergoing lower limb orthopedic surgeries using low dose of intrathecal hyperbaric bupivacaine, there was no statistically significant difference in relation to gender status between group CSE - EVE (male-70.00%, female-30.00%), SD=8.09) and group CSE (male-77.50%, female-22.50%) with a p value of >0.05 as per chi squared test. Therefore we fail to reject the null hypothesis that there is no difference in gender status between the intervention groups.

Height

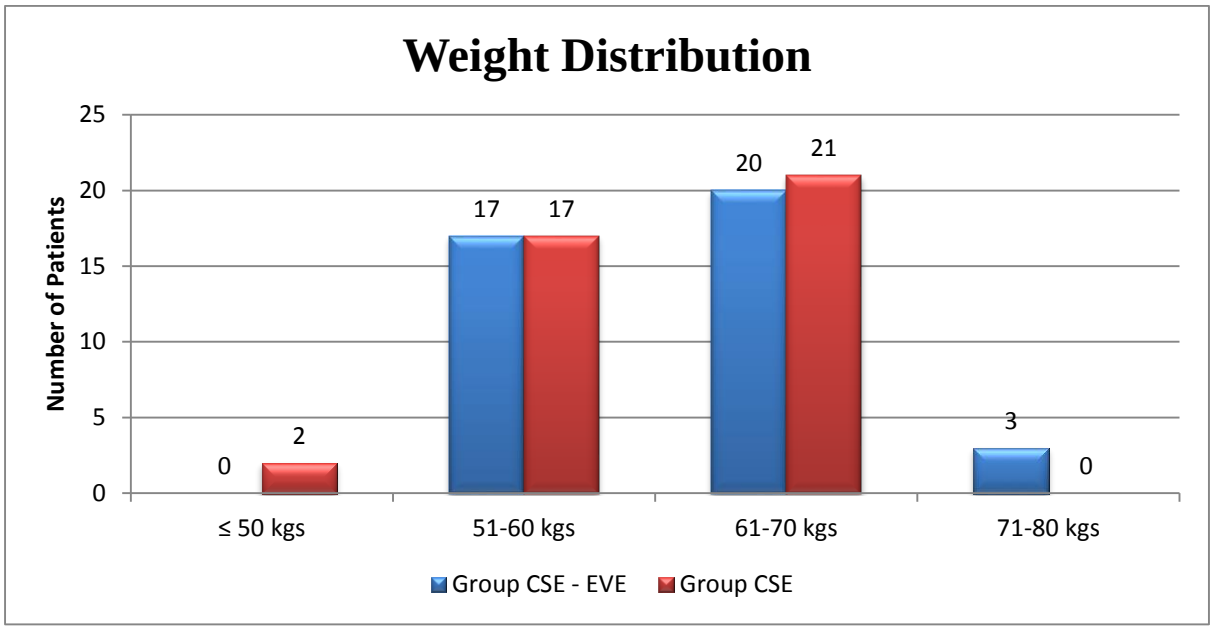


Height Distribution	Group CSE - EVE	%	Group CSE	%
≤ 150 cms	1	2.50	1	2.50
151-160 cms	21	52.50	19	47.50
161-170 cms	18	45.00	20	50.00
Total	40	100	40	100

Height Distribution	Group CSE - EVE	Group CSE
N	40	40
Mean	159.45	159.78
SD	5.80	5.52
P value Unpaired t Test		0.7981

Among the patients undergoing lower limb orthopedic surgeries using low dose of intrathecal hyperbaric bupivacaine, there was no statistically significant difference in relation to height distribution between group CSE - EVE (mean=159.45, SD=5.80) and group CSE (mean=159.78, SD=5.52) with a p value of >0.05 as per unpaired t test. Therefore we fail to reject the null hypothesis that there is no difference in height distribution between the intervention groups.

Weight

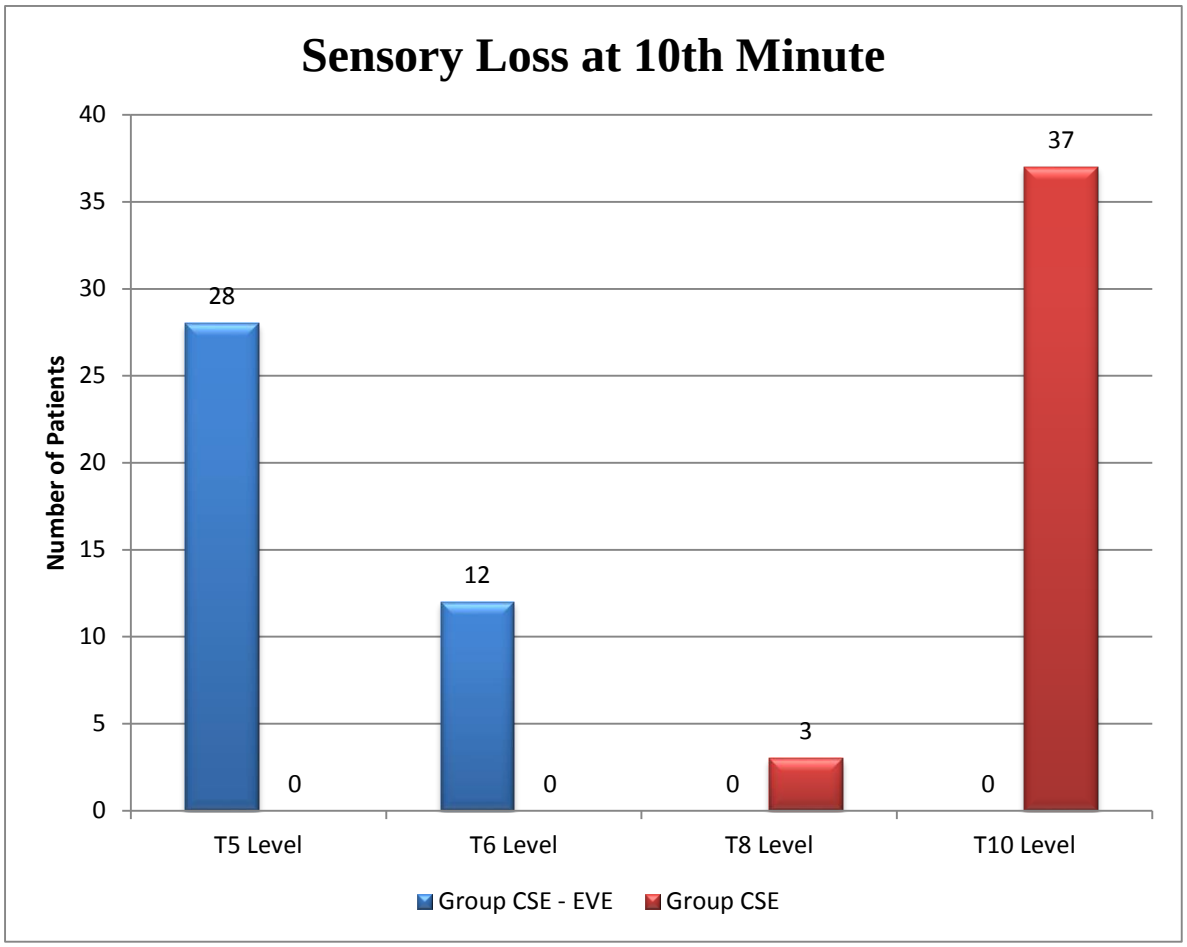


Weight Distribution	Group CSE - EVE	%	Group CSE	%
≤ 50 kgs	0	0.00	2	5.00
51-60 kgs	17	42.50	17	42.50
61-70 kgs	20	50.00	21	52.50
71-80 kgs	3	7.50	0	0.00
Total	40	100	40	100

Weight Distribution	Group CSE - EVE	Group CSE
N	40	40
Mean	62.75	61.25
SD	5.65	5.36
P value Unpaired t Test		0.2266

Among the patients undergoing lower limb orthopedic surgeries using low dose of intrathecal hyperbaric bupivacaine, there was no statistically significant difference in relation to weight distribution between group CSE - EVE (mean=62.75, SD=5.65) and group CSE (mean=61.25, SD=5.36) with a p value of >0.05 as per unpaired t test. Therefore we fail to reject the null hypothesis that there is no difference in weight distribution between the intervention groups.

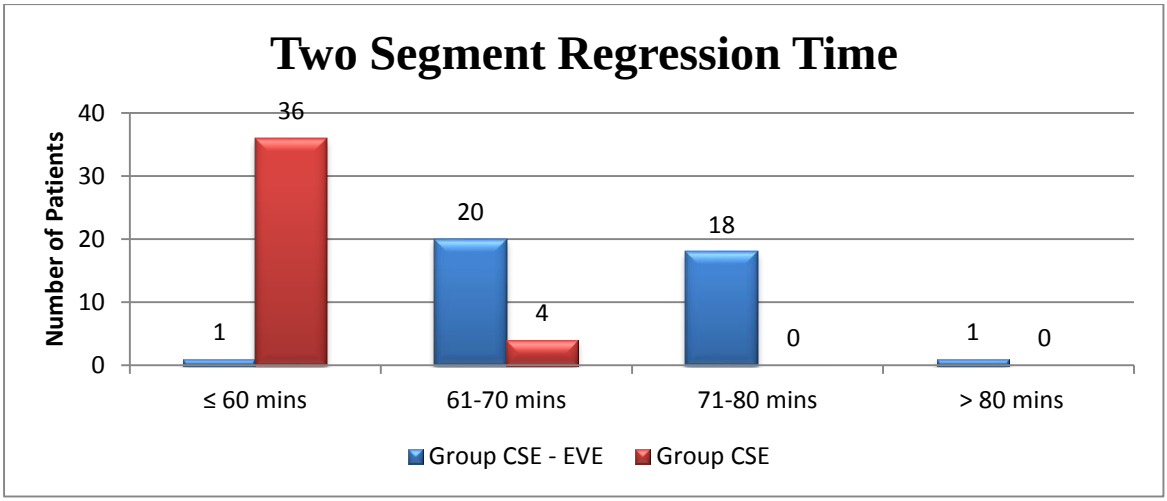
Sensory Loss at 10th Minute



Sensory Loss at 10th Minute	Group CSE - EVE	%	Group CSE	%
T5 Level	28	70.00	0	0.00
T6 Level	12	30.00	0	0.00
T8 Level	0	0.00	3	7.50
T10 Level	0	0.00	37	92.50
Total	40	100	40	100
P value Fishers Exact Test			<0.0001	

Among the patients undergoing lower limb orthopedic surgeries using low dose of intrathecal hyperbaric bupivacaine, there was a statistically significant difference in relation to sensory loss at 10^{th} minute between group CSE - EVE (majority at T5 level-70.00% followed by T6 level-30.00%) and group CSE (majority at T10 level-92.50% followed by T8 level-7.50%) with a p value of <0.05 as per Fishers exact test. Therefore we reject the null hypothesis that there is no difference in sensory loss at 10^{th} minute status between the intervention groups.

Two Segment Regression Time

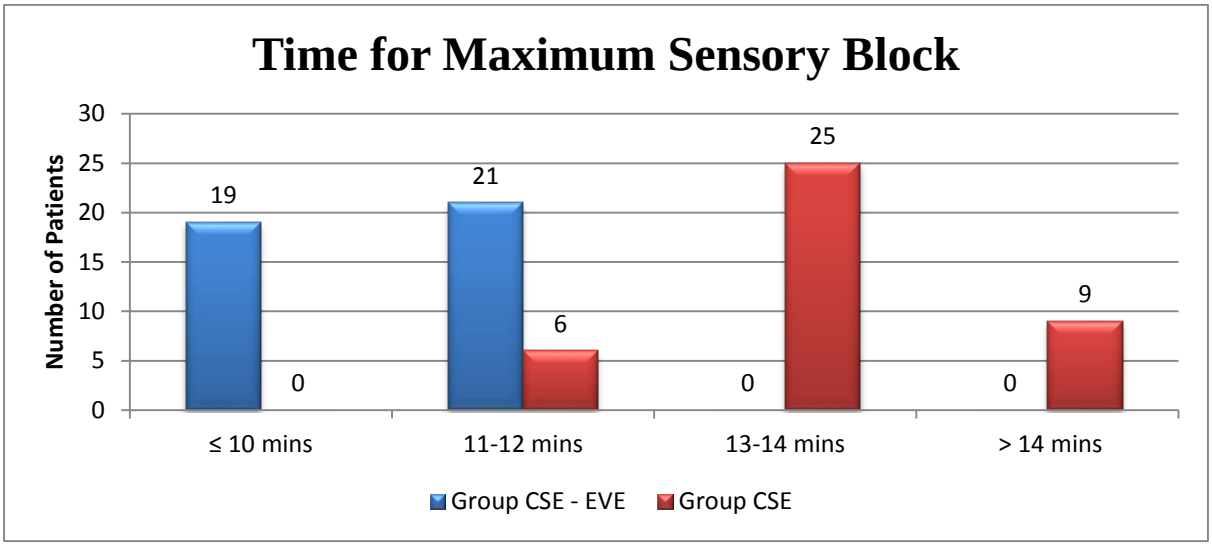


Two Segment Regression Time	Group CSE - EVE	%	Group CSE	%
≤ 60 mins	1	2.50	36	90.00
61-70 mins	20	50.00	4	10.00
71-80 mins	18	45.00	0	0.00
> 80 mins	1	2.50	0	0.00
Total	40	100	40	100

Two Segment Regression Time	Group CSE - EVE	Group CSE
N	40	40
Mean	70.00	55.90
SD	4.64	3.58
P value Unpaired t Test		<0.0001

Among the patients undergoing lower limb orthopaedic surgeries using low dose of intrathecal hyperbaric bupivacaine, there was a statistically significant difference in relation to two segment regression time of sensory block between group CSE - EVE (mean – 70.00, SD - 4.64) and group CSE (mean – 55.90, SD – 3.58) with a p value of <0.05 as per unpaired t test. Therefore we reject the null hypothesis that there is no difference in two segment regression time of sensory block between the intervention groups.

Time for Maximum Sensory Block

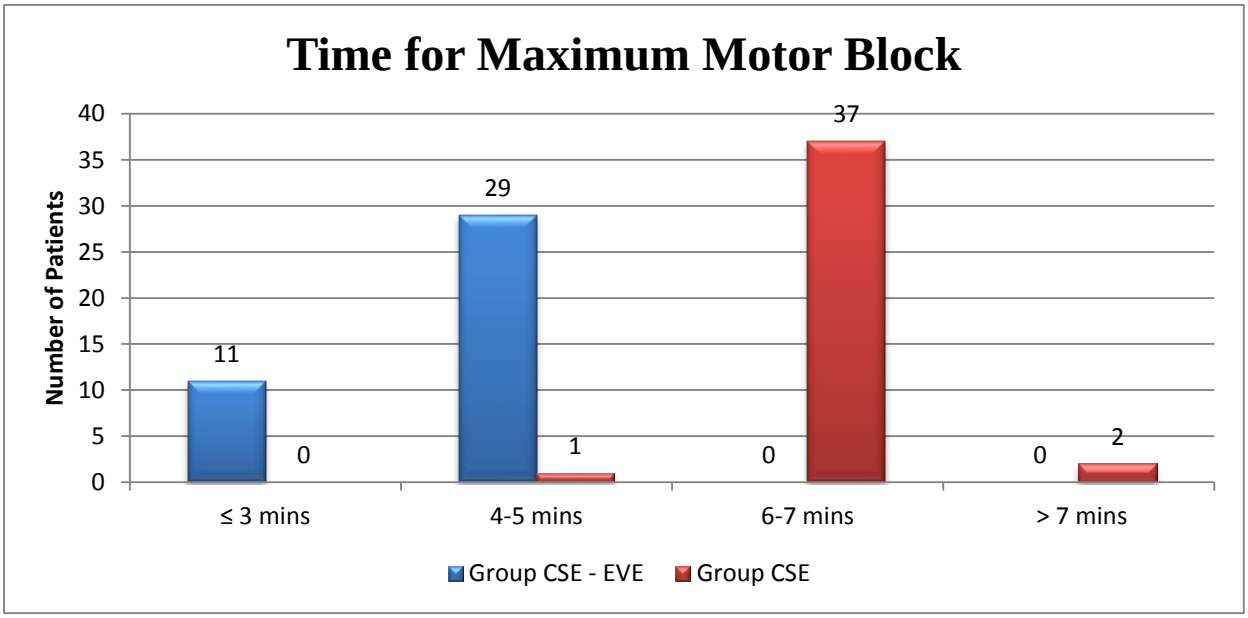


Time for Maximum Sensory Block	Group CSE - EVE	%	Group CSE	%
≤ 10 mins	19	47.50	0	0.00
11-12 mins	21	52.50	6	15.00
13-14 mins	0	0.00	25	62.50
> 14 mins	0	0.00	9	22.50
Total	40	100	40	100

Time for Maximum Sensory Block	Group CSE - EVE	Group CSE
N	40	40
Mean	10.63	13.48
SD	0.87	1.11
P value Unpaired t Test		<0.0001

Among the patients undergoing lower limb orthopedic surgeries using low dose of intrathecal hyperbaric bupivacaine, there was a statistically significant difference in relation to maximum sensory block time between group CSE - EVE (mean – 10.63, SD – 0.87) and group CSE (mean – 13.48, SD – 1.11) with a p value of <0.05 as per unpaired t test. Therefore we reject the null hypothesis that there is no difference in maximum sensory block time between the intervention groups.

Time for Maximum Motor Block

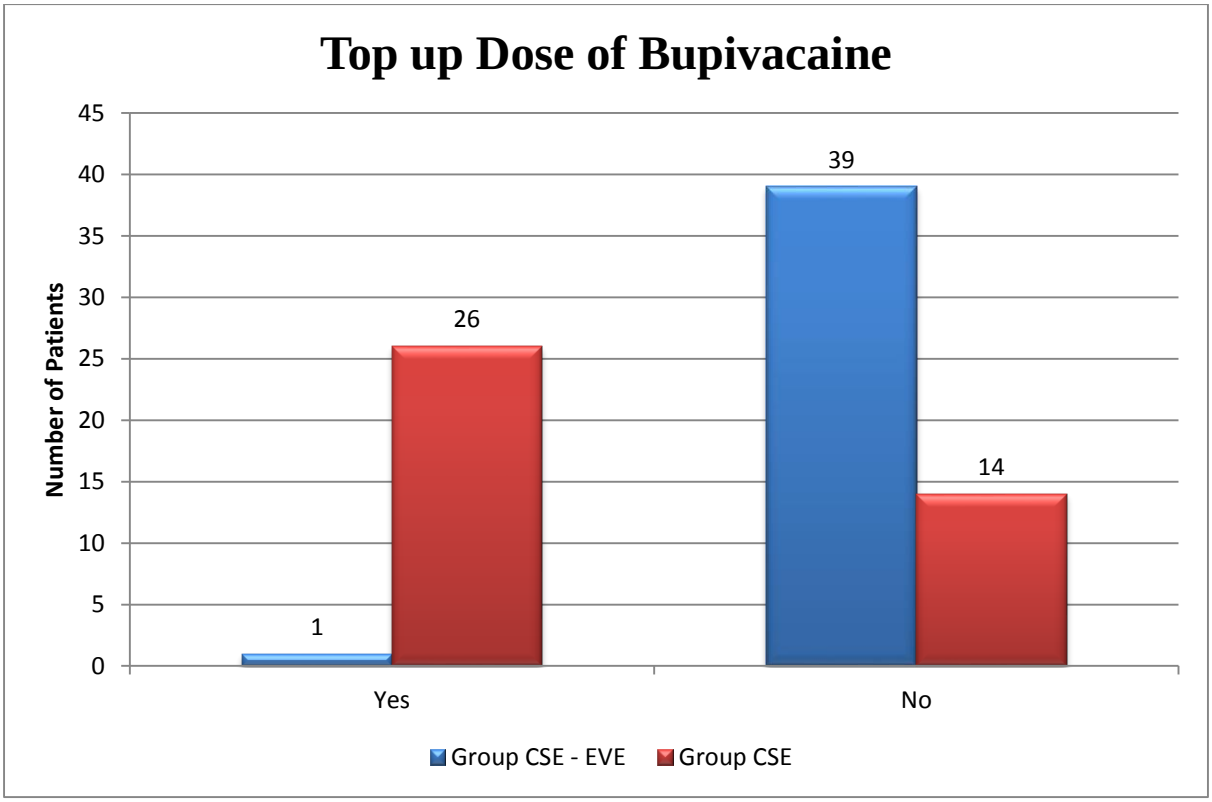


Time for Maximum Motor Block	Group CSE - EVE	%	Group CSE	%
≤ 3 mins	11	27.50	0	0.00
4-5 mins	29	72.50	1	2.50
6-7 mins	0	0.00	37	92.50
> 7 mins	0	0.00	2	5.00
Total	40	100	40	100

Time for Maximum Motor Block	Group CSE - EVE	Group CSE
N	40	40
Mean	4.00	6.43
SD	0.75	0.64
P value Unpaired t Test		<0.0001

Among the patients undergoing lower limb orthopedic surgeries using low dose of intrathecal hyperbaric bupivacaine, there was a statistically significant difference in relation to maximum motor block time between group CSE - EVE (mean – 4.00, SD – 0.75) and group CSE (mean – 6., SD – 0.64) with a p value of <0.05 as per unpaired t test. Therefore we reject the null hypothesis that there is no difference in maximum motor block time between the intervention groups.

Top up Dose of Bupivacaine



Top up Dose of Bupivacaine	Group CSE - EVE	%	Group CSE	%
Yes	1	2.50	26	65.00
No	39	97.50	14	35.00
Total	40	100	40	100
P value Fishers Exact Test			<0.0001	

Among the patients undergoing lower limb orthopedic surgeries using low dose of intrathecal hyperbaric bupivacaine, there was a statistically significant difference in relation to top up dose of bupivicaine required between group CSE - EVE (majority at T5 level-2.50%) and group CSE (65.00%) with a p value of <0.05 as per Fishers exact test. Therefore we reject the null hypothesis that there is no difference in top up dose of bupivicaine required status between the intervention groups.

DISCUSSION

Combination of spinal with epidural anaesthesia is the most often chosen and widely used method for lower limb orthopaedic surgeries. The epidural volume extension technique is an one step ahead technique which offers a good block profile. It is associated with less degree of sympathectomy that accompanies spinal anaesthesia when used alone, as the dose of hyperbaric bupivacaine used is low and hence the severity of hemodynamic compromise is also less.

The current study evaluated the effectiveness of epidural volume extension in combined spinal epidural anaesthesia to perform adequate neuroaxial blockade by low dose of intrathecal hyperbaric bupivacaine (10 mg) through epidural volume extension by 10 ml of 0.9% normal saline that was injected 5 minutes after performing the block.

Frequent failure was reported if administration of epidural saline was delayed beyond 10 minutes and the same was also proven by **Mardirosoff and coworkers**[32] who showed that for epidural volume extension to be effective, the patient should be laid supine within 5 minutes of completing intrathecal injection. **Trautman et al**[33] showed it to be ineffective when performed 20 minutes after intrathecal injection. Hence we waited for a time that was long enough to justify the use of rescue strategy for block augmentation and yet short enough for a successful epidural volume extension.

In this study, all demographic data (age, height, weight, sex) were not statistically significant between the two groups.

Regarding the block profile, there was a statistically significant difference between the two groups. The incidence of sensory loss at 10^{th} minute achieved upto T5 level was significantly higher in group CSE - EVE compared to group CSE by a percentage difference of 70.00 scoring points (100% higher). This difference is significant with a p-value of <0.0001 as per Fisher's exact test.

In this study we can safely conclude that combination of spinal and epidural with epidural volume extension with normal saline produces faster, higher and effective sensory block compared to combined spinal epidural alone as evident by significantly higher incidence of sensory loss at 10^{th} minute achieved upto T5 level .

The mean two segment regression time of sensory block was significantly higher in group CSE - EVE compared to group CSE by a mean difference of 14.10 minutes (20% higher). This difference is significant with a p-value of <0.0001 as per unpaired t-test.

In this study we can safely conclude that combination of spinal epidural with epidural volume extension with normal saline achieves an effective and prolonged anaesthesia as evident by significantly higher two segment regression time of sensory block achieved.

The mean maximum sensory block time achieved was significantly lower in group CSE - EVE compared to group CSE by a mean difference of 2.85 minutes (21% lower). This difference is significant with a p-value of <0.0001 as per unpaired t-test.

In this study we can safely conclude that combination of spinal and epidural anaesthesia with epidural volume extension with normal saline achieves effective and shorter sensory block as evident by significantly lower maximum sensory block time achieved.

The mean maximum block block time achieved was significantly lower in group CSE - EVE compared to group CSE by a mean difference of 2.43 minutes (38% lower). This difference is significant with a p-value of <0.0001 as per unpaired t-test.

In this study we can safely conclude that combination of spinal epidural with epidural volume extension with normal saline achieves an effective and shorter block time as evident by significantly lower maximum motor block time achieved.

The incidence of top up dose of bupivicaine required was significantly lower in group CSE - EVE compared to group CSE by a percentage difference of 62.50 scoring points (96% lower). This difference is significant with a p-value of <0.0001 as per Fisher's exact test.

In this study we can safely conclude that combination of spinal epidural with epidural volume extension with normal saline provides prolonged analgesia by requiring less top up dose of bupivicaine as evident by significantly lower incidence of top up dose of bupivicaine required.

With respect to the hemodynamic state, the systolic blood pressure and heart rate showed no significant changes between the two groups, which emphasized the safety of epidural volume extension technique.

Supporting the results of our study**, Aggarwal and colleagues**[34] studied the effect of different volumes of epidural saline (10, 15, 20 ml) on the level of sensory block during combined spinal epidural anaesthesia and concluded that there was a definite increase in the dermatomal segments of sensory and motor level in all patients which was volume dependent. This extension of level was not associated with significant change in pulse rate, blood pressure or respiratory rate after spinal anaesthesia.

Carpenter et al[35] used magnetic resonance imaging to demonstrate the importance of relationship between the CSF volume in the lumbar and sacral regions of the spinal cord and the peak level of sensory anaesthesia produced by hyperbaric lignocaine or plain bupivacaine.

On the other hand, **Shibuya et al**[36] recently proved that the extent of dural sac and spinal cord compression could be quantified by measuring the

dynamics of CSF flow. It was also demonstrated that the amplitude of CSF velocity and the severity of myelopathy share a close relationship. Therefore the mechanism b1ehind epidural top up could be understood by the alterations in CSF volume waveform and velocity produced by epidural saline injection.

About 1.5 and 3 ml of the epidural dose per neural segment is required to extend the subarachnoid block, which is relatively smaller than the conventional epidural dose. **Blumgart et al**[37] put forth his study on the mechanism of extension of sensory blockade to T2-T4 level following extradural injection. He divided his study population into three groups who received intrathecal injection of 1.6 - 1.8 ml of hyperbaric bupivacaine followed by 10ml of epidural saline in the first group, 10ml of epidural bupivacaine in the second group and finally the third sample did not receive any supplementary injection. He observed a significant and similar block profile in the first two groups. The authors concluded that the dural sac compression caused block extension.

Similar studies were also carried out by **Dieboid et al**[38]**, Kumar et al**[39]**, Nickalls and Dennison et al**[40]**, Brownridge et al**[41] **and Rawal et al**[42] using intrathecal hyperbaric bupivacaine and extradural administration of local anaesthetics and achieved a higher sensory block level. **Carrie and O' Sullivan et al**[43] **and Dennison et al**[44] carried out similar studies with intrathecal isobaric bupivacaine and extradural supplementation of local anaesthetic to achieve a higher sensory blockade.

A theoretical advantage of combined spinal epidural anaesthesia was put forward by **Dirkes et al**[45]**.** He declared that there is an increase in the blockade of sensory afferent nerve fibres when electrically stimulated in a combination of epidural and spinal anaesthesia compared to either of the technique used alone.

Rudolf Stienstra and Albert Dahan et al[46] randomly allotted 30 patients into groups of ten each, who were scheduled for lower limb orthopaedic surgery. All patients were anaesthetised by combined spinal epidural technique. Needle through needle method was used where a 16G Tuohy needle was introduced into the epidural space. Subarachnoid block was produced by inserting a 27G Whitacre needle into the Tuohy needle and 10 mg of plain bupivacaine was given.

After the sensory block following subarachnoid injection reaches its peak, group 1 patients received epidural top up with 10 ml of 0.5% bupivacaine, 10 ml saline was administered to samples of group 2 and group 3 received no epidural injection. The maximum level of sensory analgesia increased by 4.8 +/- 1.6 dermatomes in group 1 and 2 +/- 2.0 dermatomes in the second group. In group 3, there was an increase of 0.3 +/- 0.5 segments which was considered insignificant. Intergroup comparisons proved that this increase in dermatomal level of analgesia was significant in group 1 than group 2 or group 3 and that group 2 was superior to third group. They reasoned that it was partly explained by an epidural volume effect and partly by local anaesthetic effect.

SUMMARY

In this study,

- We observed that epidural volume extension with normal saline with low dose intrathecal hyperbaric bupivacaine 10 mg attained a higher sensory level of T5 dermatomal level.
- We observed that epidural volume extension with normal saline achieved a faster two segment regression time with a mean value of 70 minutes.
- We observed that epidural volume extension in combined spinal epidural anaesthesia lead to a quicker attainment of maximum sensory blockade with a mean duration of 10.63 minutes.
- We observed that epidural volume extension with normal saline in combined spinal epidural anaesthesia produced maximum motor blockade with a mean duration of 4 minutes.
- We also observed that almost 97.5% of patients who received epidural volume extension in combined spinal epidural anaesthesia did not require top up doses of bupivacaine.
- We observed that the demographic data (age, height, weight and sex) were not statistically significant between the two groups.

CONCLUSION

It can be concluded that low dose of intrathecal hyperbaric bupivacaine (10 mg) with 25 micrograms of fentanyl with epidural volume extension (10ml normal saline) is associated with early onset of sensory and motor blockade, high level of sensory block, shorter time of two segment regression while maintaining the hemodynamic stability.

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ANNEXURES

INSTITUTIONAL ETHICAL COMMITTEE
GOVT.KILPAUK MEDICAL COLLEGE,
CHENNAI-10
Protocol ID. No. 07/2015 Dt: 22.12.2015
CERTIFICATE OF APPROVAL

The Institutional Ethical Committee of Govt. Kilpauk Medical College, Chennai reviewed and discussed the application for approval "A Prospective study evaluating the effectiveness of epidural volume extension with normal saline in combined spinal epidural anesthesia for lower limb orthopedic surgeries using low dose intrathecal hyperbaric bupivacaine" - For Project Work submitted by Dr.S.Ashwini, Post Graduate in MD (Anaes), Govt. Kilpauk Medical College, Chennai.

The Proposal is APPROVED.

The Institutional Ethical Committee expects to be informed about the progress of the study any Adverse Drug Reaction Occurring in the Course of the study any change in the protocol and patient information /informed consent and asks to be provided a copy of the final report.

7/1/16.

DEAN,
Govt.Kilpauk Medical College,
Chennai – 10.

PROFORMA

Name:

Age:

Sex:

IPno:

Ward/ Unit

Group:

Date of admission:

Date of surgery:

ASA Physical Status:

Co- Morbidity:

Patient on any drugs:

Preoperative examination:

Blood pressure:

Pulse rate :

Room air SpO2:

Cardiovascular system:

Respiratory system:

Central nervous system:

Diagnosis:

Surgery being performed:

Investigations:

Premedication:

Time of injection of study drug:

Group (Tick any one)

Group-A: patients who received combined spinal epidural anaesthesia with epidural volume extension

Group-B: patients who received combined spinal epidural anaesthesia without epidural volume extension

Duration of surgery :

Position during surgery:

OBSERVATIONS:

INTRAOPERATIVE PARAMETERS:

Time	SL @ 10^{th} min	Time for max sensory block	Two segment Regression Time	Time for max motor block	Time to recover from motor block	B.P	H.R
5^{th} min							
10^{th} min							
15^{th} min							
20^{th} min							
35^{th} min							
50^{th} min							
65^{th} min							
80^{th} min							

PATIENT CONSENT FORM

Study Detail: **A PROSPECTIVE STUDY EVALUATING THE EFFECTIVENESS OF EPIDURAL VOLUME EXTENSION WITH NORMAL SALINE IN COMBINED SPINAL EPIDURAL ANAESTHESIA FOR LOWER LIMB ORTHOPEDIC SURGERIESUSING LOW DOSE INTRATHECAL HYPERBARIC BUPIVACAINE**

Study center: Govt. Kilpauk Medical College Hospital, Chennai.

Govt. Royapettah Hospital, Chennai.

Patients Name :

Patients Age :

Identification Number :

Patient may check these boxes

I confirm that I have understood the purpose of procedure for the above study. I have the opportunity to ask question and all my questions and doubts have been answered to my complete satisfaction. ☐

I understand that my participation in the study is voluntary and that I am free to withdraw at any time without giving reason, without my legal rights being affected. ☐

I Understand that sponsor of the clinical study, others working on the sponsor's behalf, the ethics committee and the regulatory authorities will not need my permission to look at my health records, both in respect of current study and any further research that may be conducted in relation to it, even if I withdraw from the study I agree to this access. However, I understand that my identity will not be revealed in any information released to third parties or published, unless as required under the law. I agree not to restrict the use of any data or results that arise from this study. ☐

I agree to take part in the above study and to comply with the instructions given during the study and faithfully cooperate with the study team and to immediately inform the study staff if I suffer from any deterioration in my health or well – being or any unexpected or unusual symptoms. ☐

I hereby consent to participate in this study. ☐

I hereby give permission to undergo complete clinical examination and diagnostic tests including hematological, biochemical, radiological tests. ☐

Signature/thumb Impression :

Patients Name and address :

Signature of investigator :

Study investigator's Name :

நோயாளி ஒப்புதல் படிவம்

ஆராய்ச்சியின் விவரம் :

ஆராய்ச்சி மையம் : அரசு கீழ்பாக்கம் மருத்துவக் கல்லூரி மருத்துவமனை

நோயாளியின் பெயர் : நோயாளியின் வயது:

பதிவு எண் :

நோயாளி கீழ்கண்டவற்றுள் கட்டங்களை (✓) செய்யவும்

1 மேற்குறிப்பிட்டுள்ள ஆராய்ச்சியின் நோக்கத்தையும் பயனையும் முழுவதுமாக புரிந்து கொண்டேன். மேலும் எனது அனைத்து சந்தேங்களையும் கேட்டு அதற்கான விளக்கங்களையும் தெளிவுபடுத்திக் கொண்டேன். ☐

2 மேலும் இந்த ஆராய்ச்சிக்கு எனது சொந்த விருப்பத்தின் பேரில் பங்கேற்கிநேன் என்றும், மேலும் எந்த நேரத்திலும் எவ்வித முன்றிவிப்பு மின்றி இந்த ஆராய்ச்சியிலிருந்து விலக முழுமையான உரிமை உள்ளதையும் இதற்கு எவ்வித சட்ட பிணைப்பும் இல்லை என்பதையும் அறிவேன். ☐

3 ஆராய்சியாளரோ, ஆராய்ச்சி உதவியாளரோ, ஆராய்ச்சி உபயத்தாரரோ, ஆராய்ச்சி பேராசிரியரோ, ஒழுங்குநெறி செயற்குழு உறுப்பினர்களோ எப்போது வேண்டுமானாலும் எனது அனுமதியின்றி எனது உள்நோயாளி மற்றும் புற நோயாளி பதிவுகளை இந்த ஆராய்ச்சிக்காகவோ அல்லது எதிர்கால பிறஆராய்ச்சிகளுக்காகவோ பயன்படுத்திக் கொள்ளலாம் என்றும் மேலும் இந்த நிபந்தனை நான் இவ்வராய்ச்சிலிருந்து தகும் என்றும் ஒப்புக்கொள்கிறேன். ஆயினும் எனது அடையாளம் சம்பந்தப்பட்ட எந்த பதிவகளும் (சட்டபூர்வமான தேவைகள் தவிர) வெளியிடப்படமாட்டது என்ற உறுதிமொழியின் பெயரில் இந்த ஆராய்ச்சிலிருந்து கிடைக்கப்பெறும் முடிவுகளை வெளியிட மறுப்பு தெறிவிக்கமாட்டேன் என்று உறுதியளிக்கிறேன். ☐

4. இந்த ஆராய்ச்சிஆச்ன வாயின் அருகில் வரும் சீழ் கட்டியை குறித்தது. அந்த நோயின் தன்மையையும், பின் விளைவுகளையும் பற்றியும், அறுவை சிகிச்சையின் போது கீறி எடுக்கப்படும் சீழை பரிசோதனைக்கு அனுப்பி கிருமியின் தன்மையையும் அதற்கு உகந்த மருந்தை பற்றியும் அறிய நடத்தும் ஆராய்ச்சி என்பதை மருத்துவர் மூலம் அறிந்து கொண்டேன். ☐
5. இந்த ஆராய்ச்சிக்கு நான் முழுமனதுடன் சம்மதிக்கின்றேன் என்றும் மேலும் ஆராய்ச்சி குழுவினர் எனக்கு அளிக்கும் அறிவுரைகளை தவறாது பின்பற்றுவேன் என்றும் உறுதியளிக்கிறேன். ☐
6. இந்த ஆராய்ச்சிக்குத் தேவைப்படும் அனைத்து மருத்துவப்பரிசோதனைகளுக்கும் ஒத்துழைப்பு தருவேன் என்று உறுதியளிக்கிறேன். ☐
7. இந்த ஆராய்ச்சிக்கு யாருடைய எற்புறுத்தலுமின்றி எனது சொந்த விருப்பத்தின் பேரிலும் சுயஅறிவுடனும் முழுமனதுடனும் சம்மதிக்கின்றேன் என்று இதன் மூலம் ஒப்புக்கொள்கிறேன். ☐

நோயாளியின் கையொப்பம் / பெருவிரல் கைரேகை
இடம்: தேதி:

ஆராய்ச்சியாளரின் கையொப்பம்:
இடம்: தேதி:

Group A											
Name	**Age**	**Sex**	**Diagnosis**	**Procedure**	**Height (cm)**	**Weight (Kg)**	**SL 10th min**	**Two segment regression time(min)**	**Time for max sensory block(min)**	**Time for max motor block(min)**	**Top up dose of bupivacaine**
Alamelu	55	F	Fracture Left NOF	Left Hemiarthroplasty	152	54	T5	75	11	3	no
Meena	60	F	Fracture Right NOF	Right Hemiarthroplasty	154	60	T5	64	10	5	no
Dhanasekar	47	M	United Fracture Right IT femur with Implant in situ	Implant Exit	160	65	T6	60	9	4	no
Mangaiammal	61	F	Fracture both Bone Left Leg	ORIF with ILIM Nailing	152	58	T6	68	12	3	no
Mani	67	M	IT Fracture Left Femur	ORIF with DHS Plating	162	65	T5	73	10	4	no
Sathish	44	M	Fracture SOF Left Side	ORIF with ILIM Nailing	159	67	T5	65	12	4	no
Sugumar	57	M	Fracture both Bone Left Leg	ORIF with ILIM Nailing	161	69	T6	70	10	3	no
Nageshwar	48	M	Uniting Fracture both Bone Right Leg distal 1/4th post ORIF with PO for fibula and MIPO for tibia with infected implant in situ	Implant Exit	165	67	T5	73	11	5	no
Lakshmanan	40	M	Grade 2 compound Fracture both Bone Left Leg prox and middle 1/3rd junction	ORIF with ILIM Nailing	150	58	T6	67	12	3	no
Manimegalai	43	F	Post Arthrodesis Status Left Ankle	Charnley Compression Arthrodesis	157	59	T5	75	10	4	no
Jothi	45	F	Non Union Fracture Right SOF with ILIM Nail in situ	Exchange Nailing Implant exit and Renailing with Bone Grafting	151	54	T6	69	11	4	yes
Keerthirajan	49	M	Left intertrochanteric fracture femur	DHS fixation	156	68	T5	72	10	5	no
Arjun	43	M	Extra Articular Calcaneal Fracture	ORIF with Screw Fixation	167	60	T5	68	11	3	no
Sandhya	53	F	Arthritis Left Hip	THR	151	54	T5	75	11	3	no
Manoj	57	M	Fracture NOF Right Side	DHS Fixation	155	60	T6	64	12	4	no
Nagammal	70	F	Left NOF Fracture	Cemented Hemiarthroplasty	168	65	T5	77	10	4	no
Narayanan	46	M	Left Distal tibia with Medial and Post Malleoli Fracture and Prox fibula Fracture	ORIF with ILIM Nailing and Malleolar Screw Fixation	165	72	T6	72	11	5	no
Thamesh	42	M	Fracture distal femur Left side	ORIF with Plating	158	70	T5	81	10	4	no
Ramaraj	49	M	Fracture SOF Right	ORIF with ILIM Nailing	168	68	T5	76	12	3	no
Pandiyan	47	M	Non Union SOF Fracture left side	Plating with Bone Grafting	167	61	T5	65	10	4	no
Arunachalam	54	M	Left IT Fracture	DHS	167	69	T5	75	9	4	no
Ashok Kumar	52	M	Right Isolated tibia distal 1\4th with distal Femur Fracture	MIPO Plating tibia	156	54	T5	71	11	5	no
Kumar	55	M	Left Non Union Prox tibia Fracture with Ilizarov Ring	Debridement with Ring Revision	158	64	T6	68	10	5	no
Anandh	67	M	Grade 1 compound Fracture Both Bone Right Leg	ORIF with ILIM Nailing	161	63	T5	71	12	4	no
Ilayaraja	51	M	Arthritis Left Hip	THR	164	68	T5	69	11	3	no
Chinnammal	60	F	Fracture both Bone Right Leg	ORIF with ILIM Nailing tibia	155	64	T6	75	10	4	no
Paneer Selvam	54	M	Grade 1 compound Fracture Both Bone Right Leg	ORIF with ILIM Nailing	160	58	T5	72	11	4	no
Manikandan	47	M	Left Bimalleolar ankle Fracture	ORIF with PO for fibula with Malleolar Screw Fixation for Medial Malleoli	154	59	T5	68	10	4	no
Irudayanathan	50	M	IT Fracture Left Hip	DHS	154	53	T5	70	11	4	no
Dhanasekar	62	M	Fracture both Bone Left Leg distal 1/3rd	ORIF with ILIM Nailing	165	62	T6	66	10	3	no
Egavalli	59	F	IT Fracture Left Femur	Cemented Hemiarthroplasty	169	74	T5	74	9	5	no
Govindhan	42	M	Grade 1 compound Fracture Both Bone Right Leg	ORIF with ILIM Nailing	161	64	T5	72	11	5	no
Jayalakshmi	60	F	Bimalleolar Fracture Right ankle	Fibular Plating with Medial Malleolus Screw Fixation with Syndesmotic Repair	151	58	T5	65	12	4	no
Neeradha	64	F	Fracture Right NOF	Cemented Hemiarthroplasty	154	58	T5	61	10	3	no
Saravannan	48	M	Shattered Fracture Left Tibia and Fibula	Biplanar Ext. Fixator Application	162	62	T4	68	10	3	no
Jeyagopal	49	M	Fracture both Bone Left Leg	Ilizarov Fixation	167	73	T6	62	11	4	no
Anandhiammal	66	F	Left IT Fracture	DHS	166	60	T5	70	11	5	no
Katteriyan	58	M	Right Proxial tibia fracture	ORIF with Plating	153	58	T5	71	10	5	no
Srinivasan	43	M	Malunion Fracture both Bone Left Leg	ORIF with Tibia ILIM Nailing with Bone Graft	159	65	T6	74	11	5	no
David	61	M	Fracture SOF Right	ORIF with ILIM Nailing	164	70	T5	69	10	4	no

Group B											
Name	**Age**	**Sex**	**Diagnosis**	**Procedure**	**Height (cm)**	**Weight (Kg)**	**SL 10th min**	**Two seg Regression time**	**Time for max sensory block**	**Time for max motor blockade**	**Top up doses of bupivacaine**
Rajaguru	68	M	Closed fracture Both Bone Right Leg M 1/3rd and L 1/3rd Junction	ORIF with ILIM Nailing	161	68	T10	57	13	7	yes
Muniyammal	47	F	Fracture Left NOF	Left Hemiarthroplasty	155	56	T10	60	12	6	yes
Karnan	58	M	Floating Right Knee Junction	ORIF with LCP / Bone grafting	163	67	T10	55	14	5	yes
Ganthimathy	65	F	OA Left Knee Junction	TKR	165	64	T10	53	15	6	yes
Rajeshwari	47	F	Grade 2 Compound Bimalleolar Fracture Left Ankle	Ankle Spanning Ex fix Application	167	63	T10	56	13	6	yes
Ponnusamy	45	M	Fracture both Bone Left Leg	ORIF with ILIM Nailing	156	58	T10	58	14	6	yes
Nithesh Kumar	51	M	Fracture Left NOF	Left DHS	164	68	T10	61	11	7	yes
Mahendran	50	M	Fracture both Bone Right Leg	ORIF with ILIM Nailing	154	57	T10	51	13	6	no
Rajini	47	M	IT Fracture Left Hip	ORIF with DHS Plating	152	58	T10	53	14	6	no
Thirupuram	66	F	Trimalleolar Fracture Left ankle	ORIF with Plating / Medial Malleolar Screw Fixation	169	69	T10	55	15	7	yes
Manikandan	64	M	United Fracture Both Bone Left Leg with IMIL Nail in situ	Implant Exit	166	65	T10	57	13	6	yes
Catherine	53	F	Fracture both Bone Right Leg	ORIF with ILIM Nailing	151	58	T10	54	12	6	no
Parvathy	55	F	Fracture Right NOF	Right Hemiarthroplasty	155	63	T10	58	13	6	no
Joseph	60	M	Fracture Right SOF	ORIF with Plating	165	67	T10	53	13	7	yes
Manikandan	44	M	Both Bone Fracture Left Leg	ILIM Nailing	158	65	T10	58	14	7	yes
Gajendran	59	M	B/L Calcaneum Fracture	B/L ORIF with Screw Fixation	156	58	T10	55	15	7	no
Meenu	46	F	Closed Isolated Fracture Right Tibia	ORIF with ILIM Nailing	164	69	T10	54	13	6	yes
Sudhakar	49	M	Grade 2 Compound Right Isolated Tibia Fracture	ORIF with ILIM Nailing	162	59	T10	56	13	6	no
Jayagopal	47	M	Non Union Left Distal Tibia	Ilizarov Ring Application	158	60	T10	58	12	6	no
Siva	51	M	Fracture Right NOF	DHS	168	63	T10	60	13	7	yes
Janagi Raman	50	M	Grade 2 compound Fracture both Bone Right Leg	ILIM Nailing	158	57	T10	63	15	8	no
Kannan	47	M	IT Fracture Femur	Right Hemiarthroplasty	167	64	T10	57	15	6	yes
Bharath	52	M	Fracture Right SOF	ORIF with Plating	163	68	T10	62	15	6	yes
Sekar	49	M	Grade 2 compound Fracture both Bone Left Leg	Ext. Fix for ORIF with fibular Plating	153	56	T10	65	14	7	no
Muthu	58	M	Bimalleolar Right ankle Fracture	ORIF with Medial Malleolar Screw Fixation	159	67	T10	59	12	6	no
Prem Kumar	63	M	Fracture Left SOF Distal third	ORIF with ILIM Nailing	169	63	T10	54	13	7	yes
Shanthi	45	F	Fracture Right NOF	Cemented Hemiarthroplasty	153	56	T10	58	11	6	no
Sara	48	F	Fracture Right SOF	ORIF with Plating	164	61	T10	60	13	6	yes
Kuppusamy	65	M	Grade 3 Compound Fracture both Bone Right Leg	Knee Spanning Ext.Fixation	158	59	T10	52	14	6	yes
Govindasamy	58	M	Bimalleolar Fracture Right ankle	ORIF with Plating / Medial Malleolar Screw Fixation	162	65	T10	53	13	7	no
Jeyasingh	44	M	Left Subtrochanteric Fracture Femur	ORIF with DCS	161	60	T10	50	13	7	yes
Selvamani	51	M	Fracture both Bone Right Leg	ORIF with ILIM Nailing	165	54	T10	56	13	6	yes
Ganesan	49	M	Non Uniting Fracture both Bone Right Leg with Implant Insitu	Exchange Nailing with Bone Grafting	150	53	T10	54	14	7	no
Koti	63	M	IT Fracture right Femur	ORIF with DHS	153	50	T8	56	13	6	yes
Kasinathan	52	M	Grade 1 compound Fracture both Bone Left Leg	ORIF with ILIM Nailing / Plating	151	49	T8	54	13	6	yes
Venketesan	56	M	compound Fracture both Bone Right Leg	ORIF with ILIM Nailing	164	58	T10	55	15	6	yes
Kasinathan	62	M	fracture shaft of right femur	ORIF with ILIM nailing	156	65	T10	50	14	7	yes
Raju	45	M	Fracture left neck of femur	Left Hemiarthroplasty	162	63	T10	52	15	7	yes
Sudhakar	43	M	Fracture both Bone Left Leg	ORIF with plating	154	57	T8	54	15	6	no
Manohar	54	M	Nonunion left intertrochanteric fracture femur	DHS with bone grafting	160	70	T10	50	14	8	yes

BLOOD PRESSURE AND HEART RATE CHANGES - GROUP A																	
	BASELINE	**BP 5**	**BP 10**	**BP 15**	**BP 20**	**BP 35**	**BP 50**	**BP 65**	**BP 80**	**HR 5**	**HR 10**	**HR 15**	**HR 20**	**HR 35**	**HR 50**	**HR 65**	**HR 80**
1	140/80	133/74	128/85	129/88	135/87	132/94	136/87	141/96	134/94	90	86	88	82	85	82	80	81
2	128/92	126/85	121/94	130/88	124/88	126/73	131/74	137/87	135/89	87	86	84	83	81	80	81	82
3	121/82	118/80	116/72	114/71	114/67	117/72	111/69	113/71	117/65	85	83	82	81	81	79	78	77
4	127/72	125/78	127/68	124/67	127/79	122/72	124/70	125/64	126/66	87	87	89	86	87	83	85	87
5	118/88	121/76	120/68	119/76	120/74	123/70	120/69	117/73	119/80	76	78	76	74	76	77	78	78
6	127/91	128/72	124/87	121/82	121/87	120/85	126/63	127/72	121/80	79	74	72	70	69	71	76	74
7	113/78	110/83	118/88	120/71	117/66	119/80	121/68	119/66	124/84	76	77	78	80	78	77	76	81
8	124/76	130/71	131/72	128/72	127/65	126/70	130/65	129/63	128/68	85	80	77	78	76	80	83	76
9	135/72	133/68	131/71	130/82	129/73	128/65	129/74	134/62	132/64	88	87	83	80	82	80	79	80
10	130/93	131/89	133/89	129/93	129/88	131/83	132/90	134/78	130/84	76	75	74	77	75	70	73	76
11	132/82	135/81	131/79	133/81	136/82	131/81	129/80	127/71	128/81	79	80	82	85	84	79	87	85
12	124/89	125/71	128/80	127/71	123/70	127/72	126/70	119/68	121/71	77	78	87	86	84	78	82	80
13	126/64	127/67	121/70	126/66	123/70	124/64	120/68	125/61	124/63	92	90	91	88	83	82	81	80
14	138/76	133/72	132/66	134/68	133/64	130/71	128/72	127/68	129/69	78	76	72	74	76	78	80	78
15	141/70	138/71	139/74	136/73	135/69	129/73	131/74	132/71	133/69	96	90	90	89	87	85	84	82
16	136/94	132/91	131/85	135/89	115/52	120/61	124/67	127/70	128/66	86	81	81	80	76	78	77	78
17	127/91	127/80	126/73	127/71	123/65	119/71	122/62	124/63	126/68	70	71	72	73	71	75	80	81
18	117/89	108/57	102/51	111/61	116/60	117/63	113/63	115/70	119/78	75	79	80	83	82	80	79	81
19	134/70	131/66	133/68	131/71	133/65	125/62	122/73	125/72	124/69	78	76	74	75	75	76	78	75
20	110/74	103/55	101/60	109/61	112/71	117/65	120/61	119/65	121/61	76	78	76	81	80	78	78	76
21	123/76	125/67	127/70	126/68	125/69	127/71	129/73	125/63	130/72	87	84	80	79	81	79	80	80

BLOOD PRESSURE AND HEART RATE CHANGES - GROUP A																	
	BASELINE	**BP 5**	**BP 10**	**BP 15**	**BP 20**	**BP 35**	**BP 50**	**BP 65**	**BP 80**	**HR 5**	**HR 10**	**HR 15**	**HR 20**	**HR 35**	**HR 50**	**HR 65**	**HR 80**
22	136/71	133/62	134/67	130/61	132/68	123/62	124/70	127/63	129/69	82	83	84	82	80	85	86	84
23	116/69	120/72	117/65	115/67	114/72	119/65	121/63	122/70	124/65	98	93	90	87	90	87	86	87
24	106/72	104/53	101/50	110/72	112/65	117/61	120/76	123/72	122/81	92	90	91	87	86	85	80	82
25	122/78	121/71	123/68	122/69	120/71	119/74	115/67	118/72	124/62	72	71	69	68	70	70	78	76
26	132/78	129/88	127/74	128/71	126/67	120/68	121/73	119/78	125/85	74	76	80	72	74	82	80	76
27	134/79	132/76	133/80	129/90	135/76	131/82	127/62	128/88	132/79	73	74	76	80	76	78	80	82
28	121/67	119/87	123/67	124/73	126/76	134/82	131/71	135/65	132/76	87	84	85	81	76	76	70	72
29	109/67	100/63	101/53	106/67	111/73	117/68	124/71	123/72	122/67	77	80	76	76	77	82	83	80
30	128/93	129/83	126/80	121/76	124/67	120/81	119/76	118/78	121/92	78	76	75	70	76	78	82	79
31	130/87	131/81	129/78	127/80	129/71	123/68	124/69	121/71	122/67	79	76	83	76	76	80	78	78
32	130/68	132/72	129/69	131/77	132/78	124/69	126/71	127/78	134/82	79	76	76	75	78	76	73	71
33	124/67	103/56	110/68	113/72	114/71	118/76	121/82	122/78	125/79	69	72	68	70	72	71	70	73
34	127/92	126/86	106/52	112/61	119/67	121/72	123/73	124/79	126/78	87	81	78	72	76	80	77	72
35	141/69	138/88	134/83	131/91	129/83	122/78	121/74	125/68	126/74	95	94	88	84	81	88	89	93
36	137/76	135/68	134/67	133/68	132/70	131/67	131/71	134/67	135/71	81	80	79	71	79	75	82	81
37	132/79	129/80	128/79	130/68	131/71	127/72	128/83	133/76	134/72	82	75	78	81	84	89	80	81
38	143/83	139/84	136/76	135/68	132/65	130/71	128/76	137/73	138/82	71	76	80	72	70	73	71	78
39	136/65	132/71	133/82	130/72	127/67	126/68	129/72	127/69	128/75	90	87	91	88	82	81	84	82
40	129/73	128/76	127/75	125/72	126/69	124/67	123/71	124/68	125/65	76	78	80	85	78	78	79	80

BLOOD PRESSURE AND HEART RATE CHANGES - GROUP B																	
	BASELINE	BP 5	BP 10	BP 15	BP 20	BP 35	BP 50	BP 65	BP 80	HR 5	HR 10	HR 15	HR 20	HR 35	HR 50	HR 65	HR 80
1	134/71	128/72	127/71	119/72	120/68	118/72	121/70	124/69	126/65	73	76	79	83	80	77	75	76
2	127/61	123/60	121/59	124/70	120/66	117/77	108/73	110/72	116/65	76	74	76	78	80	72	74	76
3	126/81	127/71	120/67	119/68	121/73	118/67	117/75	118/68	124/69	86	88	80	82	83	85	87	89
4	135/72	128/69	127/70	120/65	121/80	116/69	117/69	117/74	119/80	72	73	75	77	78	80	82	78
5	140/76	134/62	130/72	127/62	125/82	124/73	122/69	123/63	126/62	95	92	88	89	86	83	85	87
6	138/69	125/67	127/68	130/74	129/71	127/73	122/68	123/72	125/62	79	81	85	77	79	78	80	76
7	115/72	102/67	101/52	99/54	104/62	111/68	112/64	114/67	117/72	87	86	81	83	84	86	79	81
8	121/78	118/69	111/72	113/68	116/71	118/83	120/73	115/73	124/70	76	76	78	81	79	76	78	79
9	134/71	129/67	124/73	125/78	121/68	124/69	127/65	126/74	131/88	78	79	70	71	69	68	70	73
10	137/84	131/76	122/67	119/73	123/71	120/82	122/78	120/73	119/69	93	90	89	88	87	85	86	87
11	125/79	117/73	109/68	111/73	113/64	114/71	120/68	123/75	126/86	87	89	83	76	73	72	76	76
12	132/83	129/73	130/75	126/72	126/63	121/71	124/73	125/75	128/88	76	75	76	73	70	70	69	71
13	124/76	118/72	109/68	113/73	115/76	120/68	119/72	123/63	125/76	91	87	83	80	78	76	80	79
14	118/71	105/62	92/56	92/54	103/64	112/74	114/65	123/73	128/73	76	70	76	69	78	75	73	72
15	125/92	121/82	120/76	119/73	122/81	120/73	119/65	117/72	121/72	89	87	85	80	81	82	83	84
16	136/73	134/72	131/68	128/82	127/80	126/75	123/67	124/71	125/81	79	70	76	71	76	72	74	75
17	133/85	129/79	122/68	121/71	123/65	121/66	122/72	124/67	126/72	87	86	86	84	80	81	83	83
18	124/72	116/65	115/72	111/62	110/67	112/73	117/64	120/65	127/72	77	76	75	76	75	79	77	76
19	116/82	111/75	98/60	95/51	103/61	105/67	112/76	115/68	118/91	90	88	87	88	80	78	79	78
20	122/87	119/78	115/71	111/69	115/68	120/81	117/85	125/79	122/71	75	78	75	76	72	79	76	76
21	117/78	116/65	108/72	107/65	111/61	113/65	115/72	121/65	125/79	83	89	81	87	87	84	85	82
22	107/65	105/64	103/62	100/51	103/62	106/61	111/72	114/74	115/68	75	78	76	77	80	73	76	80
23	112/73	108/64	105/61	110/62	114/60	115/73	122/69	117/71	120/66	97	89	84	85	80	81	79	80

BLOOD PRESSURE AND HEART RATE CHANGES - GROUP B																	
	BASELINE	BP 5	BP 10	BP 15	BP 20	BP 35	BP 50	BP 65	BP 80	HR 5	HR 10	HR 15	HR 20	HR 35	HR 50	HR 65	HR 80
24	127/87	126/74	125/66	121/72	118/75	114/62	120/78	118/69	125/75	86	84	79	78	74	76	78	76
25	124/70	126/68	127/59	121/63	126/71	128/68	122/74	120/87	125/77	78	79	76	72	76	76	72	71
26	131/69	129/73	127/68	125/69	121/71	117/89	118/81	121/78	123/69	89	87	87	78	77	74	80	79
27	137/94	131/82	126/78	125/71	123/67	122/71	128/58	130/72	127/64	94	89	87	86	79	80	85	83
28	135/69	133/61	127/73	128/68	126/61	128/72	130/71	129/65	127/61	87	82	80	79	79	80	83	82
29	143/82	137/82	136/74	135/68	129/62	127/76	134/82	132/73	128/87	79	79	76	77	76	75	74	74
30	136/74	130/71	127/68	125/63	126/78	123/61	124/68	121/72	131/73	82	80	81	83	80	79	78	80
31	127/62	121/70	123/72	126/84	128/83	130/74	131/71	128/70	134/76	85	87	84	84	79	79	76	76
32	116/82	109/70	113/68	107/64	106/62	107/71	112/68	117/62	109/82	77	75	73	72	76	75	73	71
33	124/95	119/87	121/82	119/79	117/82	121/75	116/71	122/65	123/68	80	84	81	83	79	75	78	77
34	133/86	131/77	132/74	130/83	128/74	126/73	125/69	122/67	121/68	85	85	89	87	84	87	88	82
35	108/87	106/77	110/72	107/64	102/61	104/71	111/68	113/72	106/58	82	79	78	76	79	83	81	82
36	117/85	115/77	113/68	110/61	114/89	109/77	115/67	110/72	116/66	76	80	78	76	78	79	80	81
37	123/74	120/65	119/75	117/74	122/73	126/68	121/73	124/69	130/74	92	90	90	89	87	86	89	87
38	138/84	130/79	137/75	133/70	126/70	122/72	128/64	125/69	135/78	76	81	84	81	79	79	73	76
39	142/75	136/69	138/78	132/65	129/71	127/59	123/60	135/63	137/73	68	68	70	71	71	69	72	73
40	125/68	120/77	115/66	111/71	109/63	106/57	108/59	112/65	117/68	74	76	71	70	75	76	71	75